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ABSTRACT

This paper describes the highlights of a review of both commercially available videodiscs and research prototypes that was undertaken for the Interactive Videodisc Project, and sets out design principles suggested by the best examples, which take advantage of the unique characteristics of laser videodisc technology. Design options on three levels of interactivity are considered, with emphasis on Level 1 (ordinary videodisc player, with a handset for play, still/step, scan, fast forward, and reverse), and Level 3 (player attached to an independent computer, with the computer controlling the player). Level 1 design options discussed include use of variable motion, forward and reverse, and use of audio tracks; the Level 3 design options discussed include simulations and databases. Finally, certain exemplary discs are described which have made the most of the medium by intermixing the various symbolic forms, allowing each to play the role for which it is best suited. A list of the 30 videodiscs that were reviewed is provided. (3 references) (EW)

BANK STREET COLLEGE OF EDUCATION

CENTER FOR CHILDREN AND TECHNOLOGY

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Laser videodisc technology places considerable power in the hands of designers and users of educational materials for children. The unique potential of videodisc requires the designer to approach the development of educational programs in different way than for other media, such as books, films, filmstrips, or computer programs. However, as McLuhan (1964) observed, there is initially a strong tendency to simply transfer the content and approach of the old medium to the new. Thus, in many cases, educational films, filmstrips, photo archives, and encyclopedias have been put on videodisc with little concern for the unique power of the new medium other than for storage. The Interactive Videodisc Project undertook a review of existing videodiscs in order to provide an analysis of how this unique power has been used by designers. In this paper, we describe the highlights of our review and set out design principles suggested by the best examples.

We reviewed some commercially available discs and some that are research prototypes or were designed for specific purposes (see Videodisc References for a list of the discs). Our review includes many discs that we saw demonstrated but could not interact with extensively; in some cases, we did not obtain complete "discography" information. Although our review is not exhaustive, we attempt to provide multiple examples of features that illustrate exceptionally good use of the medium.

The discs were generally in a CAV (constant angular velocity) format, which allows for random access search of 54,000 frames for each side of a standard 12-inch disc. When played at the normal speed of 30 frames a second, the disc can hold a half hour of moving video with two audio tracks (accessible only while playing forward at normal speed) on each side. These discs are usually played on a machine that allows for frame-accurate random-access search, play forward or reverse, fast forward or reverse, scan (very fast) forward or re-

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*The work of the Interactive Video Project was supported by CBS, Inc. and Sony Corporation of America.

verse, single frame step forward or reverse, and choice of the two audio tracks. Our review does not include the related technology of CD-ROM, a new optical (laser) format for storing digital data that can be read and processed by computer. Application of this format is strongest in the area of text databases. It is not currently suitable for moving video, and the storage capacity for still, video-quality images does not match that of the current CAV format.

Our review also included various "levels" of interactivity. Since the kinds of interactivity are important for our analysis, it will be useful to define them at the outset. A level 1 system is a videodisc played on an ordinary player, usually controlled by a handset with buttons for play, still/step, scan, or fast forward and reverse, as well as a numeric keypad for specifying frame or chapter numbers. A level 2 system requires a smarter player, one that can read a simple control program encoded on the disc and give the user options and choice points. A level 3 system hooks the player up to an independent computer, often using a specially designed interface card. In such a system, the computer controls the player and the user controls the computer by using the keyboard or other input devices such as a mouse, joystick, grapnics tablet, light pen, or touch screen. In levels 2 and 3, the program can command the player using any of the controls available to the level 1 user (e.g., search to a frame and play forward using sound track 1; show a sequence of still frames at 2-second intervals). The program can also perform computations, such as keeping track of scores and recycling to previous segments conditional on user input. With these systems, it is also possible to display text or graphics originating in the microprocessor. Some level 3 configurations can overlay the graphics or text on the video image. Less sophisticated player-computer interfaces require either separate screens for video and computer output or toggling between the two outputs.

Our review focused mainly on levels 1 and 3. It was difficult to get the proper match of disc and player for level 2 discs, although we could play them at level 1 and get the gist of the basic structure. For level 3 systems, it was difficult to obtain the proper hardware configuration. However, demonstrations by the developers or special demonstration discs gave us access to these complex systems.

This paper reviews the ways in which designers have used the options provided by level 1 and level 3 controls. The final section discusses how certain exemplary discs have made the most of the medium by intermixing the various symbolic forms, allowing each to play the role for which it is best suited.

Design Options for Level 1 Control

If a movie were transferred from videotape to videodisc, very little would be gained because the original program was not designed to be stopped, played backwards, speeded up, stepped through frame by frame, or switched from one audio track to another. The user of the videodisc would be able to do all these things, but in most cases would have no reason to. Many educational discs designed for children consist of a compilation of instructional film documentaries, coupled with text screens with additional information or review questions (see, for example, ABC's Physical Geography, MECC's Introduction to Economics, ETS's Decimals and Fractions, and WICAT's Videodisc in Science Education, Music Is, The World of Work, and Villa Allegre). However, by expanding our analysis to entertainment discs created for children and educational and entertainment discs created for adult audiences, we did identify a number of discs that utilize the special features of the technology to provide the user with interesting and novel learning options. Among the level 1 discs, two child-oriented discs designed for home entertainment--the First National Kidisc and Fun and Games--are exemplary in their use of the video and audio options afforded by the medium. These and several other discs are the basis for our analysis of the use of level 1 video and audio design options.

Use of Variable Motion

A striking feature of videodisc play is the ability to change the speed from very rapid scan to fast (usually three times usual play), to slow, and to freeze frame (unlike videotape, a videodisc can display the same frame indefinitely without wear). Both the First National Kidisc (FNK) and Fun and Games (FG) contain segments which encourage children to use the slow motion, freeze frame, and step frame options. These options were instrumental in several ways:

Time to follow hands-on activities. Several segments on the FNK and FG discs feature arts-and-crafts activities performed in real time, such as how to make shadow puppets, tie knots, and create Japanese origami (paper folding) figures. While the normal playing speed of the disc segment allows the child to grasp the general flow of actions and steps entailed in the art project, true participation requires the child to slow down and step through the disc segment in order to catch up to that particular step in the procedure. Other lengthier activities, such as kite building and pinata making, are presented via speeded-up motion (presumably to use fewer frames). As a result, slow motion and freeze frame for these segments would be even more important.

Another novel use of slow motion or freeze frame for a craft activity is found in a segment on creating animated cartoon flipbooks. The general introduction of the principles of cartoon making (i.e., changing each picture in the sequence only slightly) is followed by a number of examples of children's animated creations. Examining these cartoons in slow motion provides a different type of cartoon experience, while step and freeze frame options allow the user to copy or recreate the same cartoon by seeing each individual picture that comprises the cartoon. Thus, the same segment can either function as a general overview of particular examples or as a detailed, how-to set of instructions.

Examination of rapid or complex motion. Slow motion and freeze frame can provide the viewer with new insights into physical movement. FNK and FG have segments featuring sleight-of-hand card tricks and magic tricks. The disc prompts the user to slow down the motion in order to figure out how the tricks were performed. Another segment, "Athletes in Motion," presents various complex physical motions, such as pole vaulting and diving, and invites the user to slow down the motion to see how the actions were accomplished. Thus, the same segment can function both as an entertaining display of magic tricks and athletic feats, or as a problem-solving environment in which to explore motion in a new way.

Surrogate travel. Slow motion and freeze frame make it possible for children to inspect more closely details of objects and scenery in surrogate travel situations. Segments of FNK and FG feature very rapid, time-compressed travel segments created with a slow-paced camera moving through various landscapes: walking through a zoo, going on a tour of Universal Studios, and flying over land in an airplane. At normal speed, the user feels as though she is traveling at extremely high speed. In order to get a closer look, the user must either use slow motion or freeze on a single frame. A segment dealing with travel through a small town presents a trivia quiz that asks for such details as the name of the hardware store and the number of people who got off the train. Children are encouraged to go back through the disc segment to pick out the answers by slowing down and freezing on the relevant frames. Thus, the same segment can provide both supersonic surrogate travel and an environment to inspect more closely features of the landscape.

Difficulty levels of game play. Both FNK and FG feature videogame-like segments requiring hand-eye coordination. The children are faced with rapidly presented visual stimuli and prompted to press the freeze frame button as soon as a certain object or pattern appears. The target (type of monster, dot at the center of a bull's-eye, or stop sign in a surrogate travel segment) usually occupies a

single frame. In order to make the game easier, the user can play the same game using slow motion, or use step frame to sneak up to the winning frame making the game trivially easy.

It should be noted that with most videodisc players audio is only possible during regular play of the disc. Thus, there is a clear trade off for such options as slow or fast motion, or freeze or step frame. In a study reported by Tally and Char (1985), children noted this problem with many of the activities on FNK and FG, although the sacrifice of the audio was not always a significant disincentive to exploring the visual options.

Forward and Reverse

In our review of discs, we found that only a few disc segments prompt the user to exercise both forward and reverse directionality. However, even when not prompted, children often find reverse play amusing. Tally and Char (1985) reported that children enjoyed using reverse to see people walking backwards or to make a frisbee-catching dog appear to be throwing the frisbee to his owner.

Elsewhere in FNK and FG, the designers used directionality intentionally. In the videogame segment, where children press the freeze frame button when they see a red center in a bull's-eye target, it is possible to play the game backwards. Instead of reacting to a visual pattern in which colored circles move rapidly toward the center, users can play the game in reverse, responding to the colored circles as they radiate outwards from the center. In a "boardgame" segment on FG, players step through the spaces of the game board according to the roll of a die. Similarly, when the player lands on a penalty space which instructs the player to move back three spaces, the child steps back through three frames.

Use of Audio Tracks

Videodiscs have two audio tracks available during normal forward play. Stereo sound is a possible application, but was not widely used in the discs we reviewed (TV monitors do not provide stereo speakers). Very often, only one track was used or both tracks contained the same thing, but in several interesting cases the sound options were put to valuable use.

Narration and answers. The FNK and FG discs provide several cases where a second audio track is used for narration. For example, segments showing dancers are accompanied by music only on one track, and by an explanation with music in the background on the second track. In other segments, children can be heard speaking pig

latin, playing charades, or performing semaphore patterns. On the alternative track, the answers are given.

Increasing the amount of information. The audio tracks have also been used to double the amount of verbal information provided by the disc. For example, FNK and FG contain segments featuring jump-rope and hand-clapping rhymes, with each track providing different rhymes. Similarly, the WICAT Videodisc in Science Education and the Grolier Body Disc use both audio tracks to present different commentaries to accompany film clips. For example, while showing an X ray of someone bending and extending his leg, the different audio tracks provide the Body Disc user with information on the bones of the leg and the cartilage of the knee. Interestingly, the disc features two commentators with distinctly different voices, so that one can readily differentiate between the two tracks when flipping back and forth between them.

Presenting different kinds of information. Rather than simply increasing the amount of information available, the audio tracks can be used to present different kinds of information. The NASA Apollo Space disc, for example, has the voice of the astronaut on one track and Mission Control on the other. The Vincent Van Gogh disc has a critical commentary on Van Gogh's life and painting on one track, and "first person" excerpts from Van Gogh's letters on the other. On the FG disc, one track of a segment on yo-yo techniques is directed to novices; the other track is aimed at experts. Other segments on FG concerned with kite and pinata making provide step-by-step instructions on one track, and historical background information on the other. The Patterns disc uses one audio track for a song about the man and cat characters in the story, and the other for a host voice-over suggesting that the child viewer look for particular circle and stripe patterns on the man's clothing and cat's coat.

A particularly provocative use of dual audio is found on Murder, Anyone?, a murder mystery entertainment disc. Here, the audio is used to create different storylines and casts of characters from the same set of visuals. Depending on the particular pattern of switching between the two tracks, 16 different stories can be experienced. For the same segment, the dialogue of the characters may be heard on one track and a voiceover by the detective may be heard on the other. For example, on one audio track, a young girl is portrayed as the sweet and innocent niece of the murdered millionaire; on the other track, the same actress is depicted as a conniving individual who has recently escaped from a girls' detention home. Thus, the different audio information actually changes the video's meaning.

The design options for level 1 control center around the unique technical capabilities of the CAV videodisc and player. We have illustrated cases where these features have been used to create programming that goes well beyond what is possible with other media. When we turn to consider level 3 (computer controlled) options, we see that many of the same issues apply because the computer program has the same options as the level 1 human user. The computer can play the disc forwards or backwards at variable speeds and switch audio tracks. The designer of a level 3 system has at his or her disposal both the flexibility of the videodisc and the power of the computer. However, in reviewing level 3 programs, we noticed that designers often fail to pass the level 1 flexibility along to the user. In many cases, these systems ignore the interesting options of speed, directionality, and audio in their choice of materials. Furthermore, even when interesting materials are placed on the disc, the computer program often strictly controls what the user can do. If a segment of motion video is being played, the user can not freeze it or run it backwards or play it a second time. The level 1 keypad is overridden by the computer, and often the program does not provide the user with alternative means of input. However, in the next section we review many exemplary level 3 programs, which take the medium well beyond what is possible with either videodisc or computer programming working alone.

Design Options for Level 3 Control

The level 3 programs that were of most interest fall into two general categories: simulations and databases. We did not seek out for review those discs that were designed for mastery of particular instructional objectives characteristic of adult training materials. However, we found that many of the simulations and databases can serve very well as learning environments in their specific content areas. In these systems, the user has a good deal of control in searching for the information that she needs; feedback about "wrong" moves is in the form of seeing what would happen if the moves were made. Simulations and databases contain many of the most interesting level 3 videodisc applications, perhaps because they turn control over to the user, thus utilizing the random access capability of the medium.

In level 3 systems, the disc player is controlled by the computer, and much of what makes the systems interesting is the computer program. (Almost any computer can be used to drive a videodisc. Most current systems use microcomputers, such as the IBM PC or Apple II; older prototypes often ran on minicomputers, such as the VAX, making them virtually inaccessible outside of the laboratory). However, what

really makes level 3 exemplary are the combined strength of the computer and the unique features of the videodisc medium.

Simulations

A number of interesting simulations illustrate the ways in which the user can assume the role of scientist, doctor, or lawyer at several levels of expertise. Another type simulates travel through a landscape, thereby offering a "surrogate travel" experience. These discs are generally used in training, but also provide a self-paced experience of exploration or problem solving.

Role-playing: Scientist, doctor, lawyer. Several simulation discs make it possible for the user to exercise some control over the type of scientific or diagnostic procedures conducted. On the Puzzle of the Tacoma Narrows Bridge Collapse disc, a physics disc for college and high school students, the user is presented with the problem of why a bridge collapsed, and has the option of conducting experiments which control or vary different variables using footage of a scale model of the bridge under different conditions. Under level 2 control, the user can choose different wind velocities (slow, medium, or high) at different pulsating rates (low frequency, high frequency, or steady), and observe the resultant effect on the bridge model.

In the Medical Diagnostic simulation produced by WICAT, the user assumes the role of doctor, and sees a film clip of a patient describing his symptoms and complaints. Choosing from the array of possible diagnostic procedures, the user can elect to perform various invasive techniques (e.g., placing a probe down the patient's throat), or laboratory tests (e.g., requesting an X ray or blood test). The user then makes a diagnosis based on these techniques and laboratory findings, and receives feedback as to the accuracy of the diagnosis.

One of the more interesting simulations, Ortiz v. Fleishman, was created by a law professor at New York University. The user assumes the role of defending attorney, and sees her client being cross-examined by the prosecuting attorney. The user must recognize when there are sufficient grounds to object to the prosecutor's line of questioning, and know on what grounds to make such an objection. The judge on the videodisc then gives feedback as to whether the objection is sustained or overruled, whether or not the grounds for objection are appropriate, and whether the user should have objected earlier in the line of questioning (e.g., "It's about time, Counselor").

In contrast to other simulations that provide a video "lead in" to set up the problem context, after which the user can select various options from a database of procedures, the law simulation is more highly interactive in that the user almost "converses" with the videodisc presentation. In effect, there is a much closer tie between the simulated experience and the user's response, regarding both causal and temporal relationships, than that incorporated in most videodisc simulations, which generally entail only contextual relationships.

Another interesting aspect of this legal simulation is its integration of an on-line legal database. The simulation offers two different modes of interaction. The first takes place in the courtroom, where the user responds to the actions of the prosecuting lawyer, his client, and the judge. The second is a research mode where the user can presumably call a recess, and have a certain amount of time (kept track of by the computer) to refer to various legal documents in an on-line database. Thus, this integration of a simulated problem context with an easily accessible database provides a particularly powerful combination of problems, focused inquiry, and intervention strategies.

A few simulations also present different types of feedback or solutions to the user, depending on the user's background. For example, the Tacoma Narrows disc distinguishes between different levels of user knowledge of algebra, graphs, forces, and Hooke's Law, and offers different types of explanations and problem solutions accordingly.

Similarly, the NYU legal simulation offers different types of feedback from the judge depending on the user's level of legal knowledge: For more experienced law students, the videodisc judge reprimands frequent and inappropriate objections, as well as appropriate but late interventions by the "lawyer." The judge also requires from advanced students more subtle distinctions in their grounds for objections.

Surrogate travel. An interesting genre of simulation was pioneered by the Architecture Machine Group at MIT with their Aspen disc (also featured on the MIT Discursions disc), which allows the user to simulate the experience of moving through the town of Aspen. However, unlike the rapid, linear travel featured on the level 1 FNK and FG discs, there is some choice in the desired path of travel. For example, the user can drive down a road in one direction, and then head back in the other direction (in contrast to reverse directionality using the level 1 keypad, where one only feels as though one is driving backwards). It is also possible not only to elect to observe what is straight ahead down the road, but to choose to see the sights to the right and left. Furthermore, the user can decide to go straight ahead, right, or left at an intersection, as well as to walk

into different buildings to explore their inner space. And (quite magically) one can also choose whether the different legs of one's journey in Aspen take place during winter or summer.

The Berlin disc, developed for the U.S. Army by the Interactive TV Company, is an even more sophisticated surrogate travel disc. As with the Aspen disc, the user can select different paths of travel, that is, whether to go down a particular road or turn at an intersection. However, the Berlin disc allows the option of traveling by car or by airplane; the user who decides to fly over the city can choose one of two altitudes.

For both the Aspen and Berlin discs, various maps are at the user's disposal. With the Aspen disc, when trying to figure out what to do at an intersection, one can call up a map to help locate one's present position or where one is trying to head. The Berlin disc not only allows the user to call up a map of the appropriate area corresponding to her current spot, but also allows her to access five different maps of different scale and magnification. Furthermore it is possible on the Berlin disc to navigate right on the map by moving a red cursor along the different streets indicated, and then to click a button to get an actual street view of where one would be standing. Thus, both discs provide an extremely flexible exploration of a geographic region, with the aid of first person, simulated travel, and map representations.

Databases

For many of the level 1 discs, there are two predominant methods for selecting information. On the one hand, many of the discs are arranged in chapters, roughly corresponding to large, conceptual "chunks" of information consisting of various film sequences, or series of still frames of photographs and text screens. For example, the Vincent Van Gogh disc consists of 17 different chapters, including a film of Van Gogh's life in Arles, and a visual catalogue of his paintings during the Arles period. Using the videodisc player's keypad, one can type in a particular chapter number, use the SEARCH function, and call up that chapter so it appears (almost instantly) on the screen.

On the other hand, some of the level 1 discs (mainly those that are archival) also provide paper indexes with the individual frame numbers of the different film segments or still frames. So, for the Bio Sci and Space discs, one can refer to the index, type in an individual frame number, use SEARCH, and call up an individual picture or motion sequence.

While such search strategies have clear advantages over linear, nonrandom access videotape and film (which would entail slow, laborious, and inaccurate fast forwarding and rewinding of tape), both search functions are clearly analogous to the ways in which one would look for information in a book (i.e., by using the table of contents to find a particular chapter or the index to find a particular page).

In contrast, given the power of a database program and indexing data, there are more interesting ways to structure the design of the disc to afford more extensive and flexible methods of information access. For example, Archfile, an architecture database featured on the MIT Discursions disc, allows the user to indicate certain features or attributes of the buildings she wishes to see, such as building type, geographic location, time period, and architect. One can search the database for all the residential buildings built in New York State between 1920 and 1938. A screen then displays a stack of photographs arranged like cards in a file box. By thumbing through the individual photographs, one can receive additional information, such as the architect's name, the city and state, the exact date of construction, and the view from where the photograph was taken.

Another application demonstrated on the Discursions disc is the Movie Manual, which is concerned with auto repair. Information in this "manual" can be accessed in several very flexible ways. The main menu is a picture of a motor. Depending on what part of the motor is touched (on a touch sensitive screen), one can call up a short text description of the chapter relating to that part. By touching the chapter description, one can call up "pages" in that chapter. Some pages may feature text written in blue, with certain terms highlighted in red. The red text indicates that definitions of those terms are available and can be retrieved simply by touching them (i.e., interactive text, coupled with an on-line dictionary).

Another option available with level 3 database applications allows the user to choose how closely and thoroughly to inspect objects in the environment. In contrast to the level 1 use on the FG disc which allows children to examine a phenomenon more closely by simply slowing down or stopping the video segment, this level 3 option permits the user to zoom in on certain objects of interest and receive additional information. For example, in a pilot database application by the Getty Museum, the user might see a photograph of a Greek vase with various mythological figures painted around the rim. She then can decide whether she wants to see a closeup of any of the sections of that view of the vase, or whether she wants to rotate the vase to see what appears to the right or left of the section presented.

In a surrogate travel application by the Interactive Television Company on Waste Isolation Pilot Plant, the user can walk through a building and, upon entering a room, scan a table top with various objects on it. She then can elect to zoom in and receive additional information on any of the objects on the table. Similarly, in various flight simulations and equipment repair simulations, the user can view a photograph of something like a control panel with various dials and monitors on it, point to a particular dial, and receive more information on that feature.

These level 3 applications illustrate how the power of the computer can organize the user's access to the disc material. One of the important technical capabilities of the videodisc is as a storage device for 54,000 frames of information. The computer can help to make that vast archive accessible. Another technical capability is random access, which the computer can use to search flexibly and to structure simulations in which thousands of outcomes are possible. The full power of interactive video, however, will not be found simply by looking at the computer and the technical capability of the disc. We must also consider the content of the disc--the images that are being stored, and the mix of different symbolic forms such as photos, motion video, animation, graphics, and text. In the next section, we turn to a discussion of the interesting interplay among these forms on exemplary discs.

Making the Most of the Medium

Understanding the technical capability of videodisc and how it can be controlled by computer programming is only the beginning of successful interactive video design. The issues involved in making the most of the medium also have to do with the content of the images and with finding an appropriate match and balance for the medium. We consider two main issues: the relation of moving and still pictures, and the relation of pictures and text. The following discussions apply to discs operated at both levels 1 and 3.

Use of Single Still Frames and Motion Sequences

While videodisc has a huge capacity for still frame material (54,000 individual pictures or text pages per side), this is quickly used up when devoted to motion video at 30 frames per second. The half hour on each side of a disc makes it a somewhat inconvenient medium for storage of film material. The enormous effort required to find, code, and produce thousands of images, however, often makes a combination of motion and still frame material the optimal kind of programming. The issue arises as to the most effective use of the limited motion capacity in relation to still frame material.

A number of discs were created primarily for archival purposes, or for library or museum groups. These discs almost exclusively contain single still frames of photographs (and perhaps some identifying text frames), with relatively few motion sequences. For example, the Air and Space Museum's Archival Videodiscs I and II are entirely filled with photographs of aircraft and aircraft carriers. Many archival discs contain a mixture of still frames and motion video--for example, Optical Data Corp.'s 9-disc series of Apollo, Shuttle, and Astronomy discs on satellite and space shuttle travel. The Bio Sci disc contains both photographs and film clips from various instructional films.

Two art discs, Vincent Van Gogh and National Gallery, also use a mixture of still photos and film sequences. While also archival in nature, these two discs not only offer a large collection of still photographs (e.g., Vincent Van Gogh contains over 400 frames of original photographs, prints, and text frames tracing Van Gogh's life, while National Gallery features 1,645 photographs of paintings and sculpture), but also include more extensive use of motion film sequences than the above predominantly still, image-based discs. The Van Gogh film sequences describe the different geographic locations and periods of Van Gogh's artistic career. They also include a dramatic production of a play about Van Gogh's life. The National Gallery film sequence describe the museum's history, and a give brief gallery tour of the museum's art work.

The visual motion sequences on these two discs generally resemble linear (albeit well done) film documentaries. The Vincent Van Gogh disc features Leonard Nimoy as host and is rather "talking heads" in style, with very limited use of sequences in which motion is essential. For example, there is relatively little visual zooming in on closeups of paintings or first-person camera shots that allow the user to explore the various landscapes and village settings as Van Gogh might have done. The National Gallery disc does include more extensive use of visual zooms, closeups, and visual pans of artwork in an attempt to simulate the way someone might carefully examine and visually scan a painting. However, the disc does not include other, more innovative film techniques, such as first-person camera shots, that would make viewers feel as though they are moving from one room of the museum to another, or viewing a piece of sculpture by walking around it.

The Citizen Kane disc, documenting the film classic, also utilizes a combination of film sequences and still images. While most of this 3-disc set features the regular-playing film version of "Citizen Kane," one side of one of the discs is a "visual essay" that intermixes motion sequences with still frame screens. For example, the disc features text screens giving background information for setting up important scenes in the film, followed by film clips of those scenes, as well as

numerous still frames of photographs of pages from the original script, drawings for the various set designs, and biographical text on the actors. Thus, this disc goes beyond merely placing an intact film on disc, and ventures to approximate more closely a film buff's collection of desired materials on the subject.

It is important to note that with most current videodisc players, audio is only possible when playing motion sequences and not with a single frame of video. Thus, these motion sequences also make possible an accompanying audio commentary and the inclusion of appropriate period and program music in the soundtrack, which considerably heighten the narrative flow of the information. In addition, as is the case with the two art discs cited earlier, the viewer gets a better feel for the artists, the museum, and the art works.

Motion sequences also appear to be important in conveying the dramatic aspects of more fictional, narrative material. Murder, Anyone?, a murder mystery entertainment disc, begins with a dinner scene in which a millionaire declares to his family and numerous houseguests that he is about to change his will. He is then murdered, and a hired detective proceeds to interview the various suspects. While most of the disc is dedicated to moving footage of the detective's conversations with the suspects, there is also a database of still frames that help the user to uncover the murderer, the motive, and the method. The database consists of photographs, including close-ups of the bullet lying among the ashes of the fireplace in the study (the scene of the murder), a page from the widow's diary, and the autopsy report.

In general, in the discs discussed above, single still images have been used to present visual referents of certain objects (e.g., aircraft carriers, animals. types of terrain, paintings, murder weapons). In contrast, motion sequences have been best utilized when designed to depict dynamic actions and movements of animate or inanimate objects (e.g., cells dividing through meiosis, an astronaut conducting gravity experiments on the moon), to simulate movement or surrogate travel through space (e.g., traveling along the moon's surface in a lunar dune buggy), or to help set up the narrative, suspense, and dramatic flow of a person's biography or a murder mystery.

Integrating Text and Visual Images

The discs reviewed feature varying degrees of integration of written text and visual images (photographic and graphic, moving and still images). With level 1 discs, all text and graphics are pressed onto the disc as individual frames. In contrast, level 3 systems make possible the more highly interactive option of creating computer-

generated text and graphics that can be displayed separately or overlaid on the video images from the disc.

We reviewed one level 1 disc which uses a totally text-oriented approach to creating an electronic encyclopedia. Each frame contains a screen filled with different, alphabetized terms and explanatory text. This approach underutilizes the visual capabilities of the medium, given both the visual image quality possible on the disc and the fact that it is possible to create text screens and text overlays through level 3 software. Furthermore, the vast text-storage capacities of CD-ROM now available make the solely text-based approach to videodisc difficult to justify. On the other end of the continuum, there are archival discs which almost exclusively feature photographic and film images, sparsely accompanied by a few identifying text frames. The Bio Sci disc and almost all of Optical Data Corp.'s NASA discs contain only a few text frames. This limited integration of text and images is often a problem for the user (Char & Tally, 1985), since it is difficult to know what one is viewing when looking at a particular photograph or film clip.

Other discs, such as the Grolier Body Disc, achieve a more closely balanced focus on text and images, and intersperse text frames with either still photographs and diagrams or moving video. For example, in a lesson concerning the skeletal structure, it is possible to see some text on the bones in the neck, followed by a diagram and then a film clip of an X ray of someone moving his/her head forwards and backwards.

The Whales disc also intermixes text and images in its glossary of whale terms. Rather than traditionally presenting glossary terms with either straight text or text accompanied by photographs, the glossary on whale terms features a number of film clips depicting various whale behaviors (e.g., breaching, flippering, lobtailing), the functionality of different parts of the whale anatomy (e.g., how flippers help guide the whale through water and how the blowhole opens and closes), and whale sounds during echolocation (since, as mentioned earlier, audio is only possible during moving video for most videodisc players).

Of the discs reviewed, MIT's Discursions contains the most sophisticated integration of text, photographs, and moving video sequences. The Movie Manual, cited earlier, is a level 3 system concerned with auto repair. In one segment, a screen that describes a certain auto repair procedure might have several text paragraphs, with a 1/4 screen corner insert of a still photo. When certain features of the text are touched, the photographic insert becomes a moving video sequence of that procedure; when the image is touched again, it is

possible to receive a full-screen image of the procedure performed by the auto mechanic. This film clip can be played forwards and backwards and at different speeds (like the level 1 use described earlier), either as a full screen (with no text) or as a 1/4 screen while seeing the corresponding text in the highlighted paragraph. Another interesting aspect of this disc is the ability to see the outcomes of incorrect procedures; for example, the user is shown that if certain screws in the oil pan are unfastened too far, all the oil will come spilling out.

Another of the applications demonstrated on the MIT disc is Communication News, an interactive newspaper. The first screen resembles the first page of a newspaper, with such columns as international news and finance. By running a finger down a particular column, the user can call up the continuing text of the article (scrolling text). In addition, one can call up a photograph of the world leader cited in an article on foreign relations, or a map picture of the region where a particular news incident occurred.

Perhaps the most inventive integration of text and image is the use of objects as sources of written text. One of the interesting features of the Citizen Kane disc is the use of original source material (rather than simply text and graphics screens) as the source of written information. For example, a few of the frames feature photographs of pages from the film's original shooting script, storyboards and set design sketches, articles in Variety, and reviews that actually appeared in various newspapers, rather than reproductions of the words in new text screens. Similarly, the Murder Anyone? disc contains a number of clues showing written words in their "original form," such as a diary, an appointment book, a letter, and a telegram. Thus, both discs incorporate film devices that manage to convey a sense of the content of the words, as well as an appreciation for the actual literary object. These devices combine the information content of the disc with the medium's unique capacity for displaying high-quality images.

Conclusions

Our review and analysis has focused on the features that make the videodisc medium unique. The design options illustrated in many exemplary discs take advantage of capacities not readily found in other media, including: motion and still frame display; variations in speed and directionality; access to multiple audio tracks; rapid random access; integration of text and pictures; and computer control. In many cases, programming simply represented the transfer of material from one medium (books, photo catalogues, slide shows, films) to videodisc. In the cases we have highlighted, designers

have used the unique power of the medium to present information in new ways. The designers of educational materials for children can take lessons from these discs. In so doing, we can enliven children's learning, giving them rich databases, simulations, and other materials that would not otherwise be available.

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Apollo Space Disc, Optical Data Corp.

Archfile, on Discursions disc, MIT Architecture Machine Group.

Archival Videodiscs I and II, Natural Air and Space Museum,

Aspen, on Discursions disc, MIT Architecture Machine Group.

Astronomy Disc, Optical Data Corp.

Berlin, Interactive Television Company.

The Bio Sci Videodisc, Videodiscovery, Inc.

The Body Disc, Grolier, Inc.

Citizen Kane, Criterion Corporation.

Communication News, on Discursions disc, MIT Architecture Machine Group.

Decimals and Fractions, Educational Testing Service.

Discursions, MIT Architecture Machine Group.

The First National Kidisc, Optical Programming Associates.

Fun and Games, Optical Programming Associates.

Introduction to Economics, University of Nebraska (Nebraska Videodisc Design/Production Group).

Medical Diagnostic, WICAT Education Institute.

Movie Manual, on Discursions disc, MIT Architecture Machine Group.

Murder, Anyone?, Vidmax.

Music Is, WETA-TV, Washington, DC.

The National Gallery Disc, National Gallery of Art.

Ortiz v. Fleishman, Frank A. Bress.

Patterns, Zilberberg Productions.

Physical Geography, ABC.

Puzzle of the Tacoma Narrows Bridge Collapse, Wiley.

Space Archive Vol. 1: Space Shuttle, Optical Data Corp.

Villa Allegre, U.S. Department of Education.

Vincent Van Gogh Disc, North American Philips Corporation.

Waste Isolation Pilot Plant, Interactive Television Company.

Whales, National Geographic.

The World of Work, U.S. Department of Education.