AD-A116 423 NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN D--ETC F/G 14/3
PREMASTERING FORMATS FOR VIDEODISC.(U)
DEC 80 R HURLOCK
UNCLASSIFIED NPRDC-TN-81-5 NL

1 of 1
AD A
116423

END
DATE
FILMED
8-82
DTIC

AD A116423

NPRDC TN 81-5

DECEMBER 1980

PREMASTERING FORMATS FOR VIDEODISC

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN DIEGO, CALIFORNIA

NAVY PERSONNEL RESEARCH
AND
DEVELOPMENT CENTER
San Diego, California 92152

NPRDC Technical Note 81-5 December 1980

PREMASTERING FORMATS FOR VIDEODISC

Richard Hurlock

Reviewed by
John D. Ford, Jr.

Approved by
Richard C. Sorenson
Director of Programs

Navy Personnel Research and Development Center
San Diego, California 92152

FOREWORD

This research and development was conducted within Exploratory Development Work Unit *ZF63-522-001-010-03.03* (Videodisc Training Technology) under the sponsorship of the Chief of Naval Operations (OP-1). The findings of this effort can be used to aid in making decisions regarding selection and use of premastering formats for instructional materials.

The results of this effort are intended for use by the Navy's Instructional Program Development Centers, Chief of Naval Technical Training, Chief of Naval Education and Training, and defense training research and development community.

RICHARD C. SORENSON
Director of Programs

SUMMARY

Problem

The optical videodisc offers a new storage and retrieval capability for visual images and audio that is superior to any other medium. Videodisc manufacturers require that source material for disc production be given to them on a single common film or tape (premastering) format. The premastering format, therefore, determines what is actually recorded and stored on the videodisc. Although the selection and preparation of the premastering format may be one of the most important steps in the development and production of videodisc-delivered instruction, there is a general lack of information available to lesson designers about the advantages of various premastering formats.

Purpose

The purpose of this work was to provide information to aid in making decisions regarding the selection and use of premastering formats for instructional materials being prepared for videodisc-delivered training.

Approach

An existing instructional lesson was copied into five different formats (tape or film). These format copies were then empirically compared to determine material and personnel time needed to produce them, and to calculate videodisc storage space requirements. Also, premastering format requirements when developing original audiovisual instructional materials and when converting existing audiovisual materials for videodisc training delivery were analyzed.

Findings

1. When preparing a common premastering format for a training lesson consisting of a large number of single-image presentations combined with a series of short motion sequences, film requires less disc storage space than tapes.

2. In the preparation of original audiovisual materials, film is the necessary format for making animated motion sequences and for recording other types of two-dimensional materials held in an animation stand. Film is the best premastering format for still visuals intended to be displayed in a freeze-frame mode with the videodisc player. While

videotape is equal to film as a format for making live motion sequences, tape cannot offer a choice of lenses or film type for special conditions and special effects, and may yield a flickering image if randomly stopped in a freeze-frame mode. The advantage of videotape format is that it provides immediate feedback of recording success during preparation.

3. When converting existing audiovisual materials into a common premastering format, film can be easily transferred into a videotape format, but tape is not successfully transferred into a film format.

4. The size and resolution of videodisc displayed by images affect perception, recognition, and readability. These problems must be dealt with during the development of original hard copy and two-dimensional subjects (flat objects) and during the transfer of these materials into a premastering format. Also, aspect-ratio differences between premastering formats and existing hard copy must be resolved during transfers.

Discussion/Conclusions

The advantages and disadvantages of using film and tape formats were reviewed, and the best premastering formats for producing original materials and for converting existing audiovisual instructional materials were discussed.

Recommendations

1. Film formats should be used when recording single images and when producing animation.

2. If a mix of existing audiovisual materials is being converted for videodisc instruction, the presence of taped materials will dictate that all other formats be transferred into a videotape premastering format.

3. There are complex interactions between videodisc storage space, the quality of videodisc displayed images, the size and resolution of videodisc images, and whether original or existing instructional materials are being developed. All of these variables should be carefully studied before selecting and using a particular premastering format.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Problem

Although the selection and use of the premastering formats in the preparation of instructional materials may be one of the most important steps in the production of videodisc instruction, there is a general lack of information about this step. The premastering format determines what is actually recorded and stored on the videodisc. It also sets the physical requirements and limitations on what is seen by the student when viewing the video output during training. This lack of information about premastering formats and how they influence the design of instructional materials being prepared for videodisc is an important problem facing videodisc researchers and lesson developers.

Objectives

There are interdependencies between the desired design of instruction and the premastering format that is selected. The disc has limitations that affect the amount of material (size and density) that can be stored and displayed at one time and the picture quality and readability features that can be expected using different tape and film formats. The design phase of videodisc development must take these constraints into account and make compromises when necessary. This report provides useful data about these interdependencies and requirements.

Background

The optical videodisc is a 12-inch diameter plastic disc that can store information available from any film, videotape, printed text, transparency, audiotape, or phonographic record. The information is recorded with a laser, along spiral tracks in the form of modulated micropits on each side of the disc. Retrieval and playback are accomplished with a player that uses a low-power optical laser to read the image-producing signals from the micropits. The player then transmits these signals electronically to a television monitor and stereophonic audio amplifier system for display and sound output. The output can take the form of color or black-and-white video or of two-channel audio.

The industrial/educational (I/E) player, also referred to as an institutional player, contains a programmable microprocessor that aids in the retrieval of information stored on the disc. In addition to normal television program playback, special controllable effects include random access and stop on any preaddressed frame; forward or reverse slow, normal, and scan speeds; frame number display; and audio channel select.

When the videodisc is used to store and deliver training materials, the student loads the disc in a videodisc player connected to a TV set and uses a typewriter-like keyboard to "dial up" the lesson. The training materials are then presented on the TV screen in the form of pictures, text, and sound, and the student may interact with the instruction by typing responses and answers to questions on the keyboard.

There are three major reasons for investigating videodisc technology: (1) it offers massive audiovisual storage and rapid random access, (2) it has cost-saving potential, and (3) it can be configured into a portable, instructional delivery system. These benefits and other issues are briefly explored below.

Projected Benefits of Videodisc

The optical videodisc offers storage and retrieval capabilities that exceed those of all other media. Each side of a disc will hold up to 54,000 electronically addressed television frames (pages of visual information) or up to 30 minutes of motion and sound. The newest development will allow short audio segments within the "freeze" frame mode. The random access time to retrieve any single frame from a disc is only 2 seconds at maximum. The control interface for the player can be either human or computer. If a person were to view or look at each frame on one side of a disc for only 10 seconds continuously through an 8-hour day, it would take 19 days to see this information.

As a storage device for technical documentation, the potential of the videodisc seems very good. The Navy publishes three million pages of technical information yearly, which amounts to a stack of paper over 200 feet tall. At one-quarter page per image, the same information stored on videodisc would require about 111 discs, which amounts to a stack of discs less than 15 inches high. From the standpoint of information compression, it is clear that the floor or shelf space required for the videodisc is about 1/200 that required for the printed page.

Several studies have made independent estimates of potential cost savings and benefits of videodisc technology as an alternate method of storage and presentation when compared to film and tape formats. Schneider (1976) projected cost-savings of videodisc over 3/4 inch videocassette in a 30-minute motion visual program; he found videodiscs to be 1/7th the cost in a quantity of 100 copies and 1/20th the cost in a quantity of 1000 copies. Hawkins (1979) compared a 5000-frame program of 35mm slides with videodisc cost. When 50 copies were required, he estimated that a videodisc replication cost would be only 22 percent of slide duplication cost. Hawkins and Kribs (1979) compared slide/tape duplication versus videodisc duplication for all training media in the F-4 training program. They projected videodisc to be 50 percent cheaper.

The use of videodisc technology to provide a low-cost, portable delivery system for training was clearly described by Fletcher (1979):

> It may be that the most important feature of videodiscs is not their ability to present vast amounts of separate audio, video, and photographic information cheaply but rather their ability to freely mix digital, audio, video, and photographic information in any conceivable combination. The ability to intermingle these types of information should provide instruction designers with powerful presentation capabilities.

It should be added that these presentation capabilities are not regularly available to designers of instruction in Navy training. The programmable microprocessor of the I/E optical videodisc player is capable of providing complex branching instructional strategies to mix different types of presentations, thereby providing individualized interactive training. The weight (30 lbs.) and size (small suitcase) of the videodisc player make it especially suitable for a small, stand-alone system for delivering instruction.

Issues on the Use of Videodiscs

Important issues confronting the application of videodisc technology include the questions of when, where, and how to use it as an instructional delivery system. Procedures are needed to assist in determining when this technology will offer the most flexible and cost-effective medium for storage and presentation of training materials.

Empirical studies are needed for investigating how to use the unique features of this technology to incorporate instructional strategies that best match the types of training objectives to be taught. The ability to mix motion, still visual materials, and audio may offer new teaching techniques and strategies that have not been feasible or practical until now.

Research into training-delivery system configurations is also needed. This should include determining cost-effective mergers of the videodisc player and an external microprocessor in order to mix televised videodisc images with computer-generated displays for a unique presentation of instructional materials. An external microprocessor would also make it possible to test, record, and evaluate student progress and performance.

Steps for the Development of Videodisc Training Materials

After making the decision to use videodisc technology,[1] five major steps are required to produce and deliver the instructional materials:

1. Design and authoring of training and testing materials.
2. Formative evaluation of instruction, with student tryouts and revision.
3. Premastering format for instructional materials.
4. Mastering of videodisc (by disc manufacturer).
5. Delivery and management of individual instruction.

[1]This decision is a complex one and includes judgments about the need for the media mix to teach particular content, along with cost and environment constraints of purchasing, using, and maintaining a videodisc system. Guidelines for making these judgments are needed.

Steps 1 and 2 are universal in the production and development of learning materials in most instructional models for training. Determination of instructional strategies into which lesson content will be tailored and developed occurs in step 1, design and authoring of training and testing materials. The physical requirements of the medium and delivery system through which the learning materials will be presented influence this step. Videodisc technology imposes unique requirements that must be known and followed by the lesson designer. This knowledge includes constraints and limitations of premastering formats (step 3) and of the videodisc player and delivery system (step 5).

Step 2, formative evaluation, is important because all lesson revision must be done before the disc is mastered (step 4). Once the disc is mastered, the instructional materials cannot be changed, modified, or revised without remastering an entirely new disc. If student proficiency testing is to be included on the videodisc, it too must be submitted to tryout, and the reliability and validity for various alternative test forms must be established.

Step 3, premastering format for instructional materials, is one of the most important phases in the preparation of videodisc instruction. This step determines what is actually recorded and stored on the videodisc and sets the physical requirements and limitations on what is seen by the student during training. All instructional materials (i.e., visual presentation--motion and stills--and audio messages) are recorded into either tape or film format that is then sent to the disc manufacturer for mastering. The choice of format is important, because as little as 30 minutes of sound and motion or as much as 54,000 still visuals can be included on one side of a disc. For example, if a lesson designer wanted to show a fuel pump being disassembled into its component parts and elected to use motion sequence tape format, an entire side of a disc might be required. On the other hand, if the lesson designer had elected to use a single frame format (e.g., time compressed, single shots of the pump being disassembled using 16mm motion picture film), the materials might only use one or two hundred frames, a reduction in disc space requirements by a factor of 250. The choice of premastering format can therefore affect lesson development and disc mastering cost, quantity of lesson storage space on a disc, and length of student instructional time per disc.

Step 4, disc mastering, is carried out by the disc manufacturer. The videodisc that is mastered from the product of step 3 is a duplicate of that product, in terms of what the student will see. The manufacturers currently require that all lesson material be delivered to them for mastering on a common source material (premastering format).

Step 5, delivery and management of individual instruction, is controlled by the videodisc player hardware and system configuration. This includes the presentation and delivery modes, types of student interaction responses, kinds of branching strategies, mixes of stills and motion, speed and sequence order of visuals, presence of audio, and recordings of student performance data. What the student sees or hears has already been determined by steps 3 and 4.

In summary, the training materials designed for videodisc instructional delivery are restricted by the physical requirements imposed by disc and player hardware capabilities and configurations (step 5) and by the unique constraints of the premastering format (step 3) from which the disc will be mastered (step 4).

Premastering Formats for Videodisc Production

The premastering formats for videodisc production are film and videotape. A list of the major types of film and tape formats is presented below in Table 1.

Table 1

List of Major Film/Tape Formats

Film	Photographic	35mm (slides) 35mm 1/2 frame (film strip)
	Motion Picture	35mm (silent/optical) 16mm (silent/optical) 8mm (silent) Super 8mm (optical)
Video Tape	Broadcast (standard)	Ampex (2 inch quad) Fernseh (2 inch quad) RCA (2 inch quad) Visual (2 inch quad) IVC 9000 (2 inch helical-scan)
	Narrow	EIAJ Type (1-1/2 inch reel-to-reel) Ampex (1 inch reel-to-reel) IVC 900 and 800 series (1 inch reel-to-reel) Sony (1 inch reel-to-reel) 3/4 inch U Videocassettes (3/4 inch cassette)

EMPIRICAL COMPARISON OF PREMASTERING FORMATS

To obtain empirical data for comparing tape and film formats, an existing instructional lesson was selected and then copied into five different formats for study. These formats were: (1) 3/4 inch U Videocassette, (2) 1 inch Sony reel-to-reel videotape, (3) 35mm slides, (4) 35mm half-frame film, and (5) 16mm motion picture film.

Selection of an Existing Instructional Lesson

The first step in this procedure was to select an appropriate lesson to use as a vehicle to study the advantages and disadvantages of different formats. The major criterion was to find an experimental lesson that had been previously developed and validated as instructionally effective. A second criterion was for the experimental lesson to be in a form that would allow it to be modified to accommodate a variety of interactive instructional strategies. This would permit the lesson to be used later in the project to study effective strategies for use in videodisc instruction. The final criterion was that the experimental lesson had to be in a form (medium) that would allow it to be easily copied in different tape and film formats.

Experimental computer-based lessons developed on the PLATO IV System (Hurlock & Slough, 1976) met these criteria. From among these, the integrated control system (INCOS) panel lessons (Crawford, Hurlock, Sassano, & Padilla, 1976) were selected. These lessons had been evaluated as being instructionally effective, and over 90 percent of their content consisted of visuals in the form of interactive computer graphics. The INCOS lessons were designed to teach part-task procedural skills to S3-A copilots. Furthermore, the PLATO IV plasma display screen with its bright orange output and black background was adequate for film and tape shooting. A modified version of the INCOS lessons, presented in a "watch-and-learn" instructional strategy, was used to study formats. This version resembles a simple instructional strategy that can be used in videodisc instruction; that is, it permits the student to use the random access feature of the videodisc player to select, watch, study, and review each lesson objective whenever desired and until the student is satisfied with the level of mastery. At a later time, the strategy can be revised to be more interactive by means of a microprocessor program, without requiring further materials development or premastering.

The final step of this phase was to copy the "watch-and-learn" version of the INCOS lesson into different film and tape formats. A detailed survey of the lesson revealed that it was composed of approximately 500 stationary screen displays and 110 motion sequences.

Equipment and Procedures Used to Film and Tape Lessons

A complete list of formats, as well as equipment, lenses, film, and tape stock, used to copy the INCOS lesson is presented in Table 2. Sample shots were made with each type camera to determine best F/stop and exposure time for optimal contrast between display presentations and background. The F/stop and exposure time that were used for the final takes are also included.

The basic procedure for all filming consisted of single-frame photography of each of the approximately 500 stationary screen displays of the INCOS lessons in sequence. The

Table 2

List of Formats and Equipments Used to Copy Selected Lesson

Format	Description	Equipment (Model No.)	Lens	Zoom Range	Film/Tape	F/Stop	Exposure
3/4" U Videocassette	160-minute tape of motion sequences and still visuals	Sony Camera (silicon dioxide tube)	Canon V6 x 18 F1.6	18-108mm	Scotch 3/4" Videocassette	F1.6	NA
		1600 Sony U-Matic Recorder	NA	NA			
1" Reel-to-reel Videotape	80-minute tape of motion sequences	Sony Camera (silicon dioxide tube)	Canon V6 x 18 F1.6	18-108mm	Scotch 1" Videotape	F1.6	NA
		IVC-760C	NA	NA			
35mm 1/2 Frame Photographic Film	900-frame film strip	Olympus Pen-FT	Olympus Zuiko F1.4	Stationary Focal Length f = 40mm	Kodak Ektachrome EPT 135-36 Tungsten ASA 160	F8.0	30 sec.
35mm Full Frame Photographic Film	900 slides	Nikon F	Micro Nikkor Auto Lens F3.5	Stationary Focal Length f = 55mm	Kodak Ektachrome EPT 135-36 Tungsten ASA 160	F8	30 sec.
16mm Optical Motion Picture Film	600-foot film strip--500 single frames and *110 motion sequences*	Bolex H16 EL	Vario-switar 100 DOE Zoom F1.9	16-100mm	Kodak Plus-X ASA 50	F1.9	Single Fr: 1/50 sec Motion: 10 FR/SEC @ 1/21 sec

amount of material captured from each presentation was determined by the subject-to-camera (film) distance and by the focal point on the display. Using this technique, different amounts of the display could be photographed. Whenever possible, the most important, relevant, and critical point of attention was selected as the center of focus. If more than one relevant stimulus feature or point of attention appeared in a single display, a separate shot was taken of each. The sequence and order of the lesson materials followed the numerical order of the training objectives and the training materials within each objective. This basic procedure was modified for the 110 motion (graphic animation) sequences in the lessons. With the 35mm full-frame and 35mm half-frame cameras, a minimum of three shots was taken of each motion sequence (i.e., a shot was taken at the beginning of the motion sequence; another, at approximately the middle; and another, at the end of the sequence) to enable a viewer to conceptualize the changes that occur during the dynamic display change. With the 16mm camera, the single frame photographic mode was switched to motion mode (10 frames/second) for shooting the motion sequences.

The procedure for 3/4 inch U videocassette taping of the INCOS lesson material was similar to that used during filming. The taping time used to shoot each fixed screen display was individually determined by the amount of time required by an observer to read the accompanying text twice. When no text accompanied a display, the taping time was determined by the amount of time required by an observer to look and carefully study critical features being shown. Motion sequences were taped in real time and in their entirety. One-inch, reel-to-reel videotaping was used to record only the motion sequences of the INCOS lessons.

Analysis of Videodisc Space Required by Film and Tape

The 3/4 inch U Videocassette and 16mm motion picture film were selected for analytical comparisons of the amount of videodisc space that would be needed for their storage. These formats were chosen because a complete copy of all single images and motion sequences of the INCOS lessons had been made using them (160 minutes of the tape and 600 feet of the film) (see Table 2).

Since the motion sequences copied using 1-inch tape resulted in 80 minutes of tape (Table 2), it was assumed that the 160 minutes of 3/4 inch U tape was composed of 80 minutes of motion sequences and 80 minutes of still images. Since videotape stores 30 frames per second, each 80-minute segment of tape contains 144,000 frames (30 frames per second x 60 seconds per minute x 80 minutes = 144,000 frames) (see Table 3).

The 600 feet of 16mm motion picture film contains 24,000 frames, because there are 40 frames per foot of film (40 frames per foot x 600 feet = 24,000 frames). Of the 24,000 frames, 500 frames or 12.5 feet (500/40 frames per foot) are still images, leaving 23,500 frames comprising the motion sequences (see Table 3).

Table 3

Frames and Videodisc Space Required to Copy Lesson

Format	Motion	Stills	Combined
	Number of Frames		
Videotape	144,000	144,000	288,000
16mm Film	23,500	500	24,000
	Videodisc Space (Sides)		
Videotape	2.67	2.67	5.32
16mm Film	.44	.01	.45
Space Factor (Ratio)	6	266	11.8

Since optical videodisc can store 54,000 frames on each side of a disc, it is possible to calculate the amount of space each of these premastering formats would require. The essential variable is the number of frames comprising stills and motion sequences for each format. The space requirements are summarized in Table 3. Videotape motion (144,000 frames) required 2.67 videodisc sides of storage (144,000/54,000 = 2.67 sides), while film required less than half a side (23,500 frames/54,000 frames per side = .44 sides). Tape also required 2.67 sides of disc storage for the still images, as compared to one-hundredth (.01) of a disc side for film (500 frames/54,000 = .01 sides).

The differences in videodisc space requirements needed by film and tape premastering formats were dramatic (see Table 3). Film was highly superior to tape; it required less than half a disc side to store all the motion and still image frames of the INCOS lessons. For tape, over five disc sides were needed to store the same INCOS materials (i.e., using videotape to directly copy the still images and motion sequences would require over 11 times the disc space for storage as film would require). These data are specific to the INCOS lesson, so it is important to caution about generalizing the exact quantitative differences between film and tape.

Comparison of Materials Cost and Personnel Time Required to Film and Tape

A list of film and tape stock and development cost has been gathered and presented in Table 4. The number of hours required to film, tape, and edit each format is also shown. The cost of cameras and recorders has been omitted, because of the wide variety, quality, and range of prices available.

Although 35mm slides can be edited in one fifth of the time that it takes to edit tapes, they take twice as long to film. Further, it takes twice as long to edit and to photograph 16mm film as it does to edit tape. Videotaping appears to be the fastest and least expensive method to copy an existing computer-based instructional lesson from a display screen.

Table 4

Materials Cost and Personnel Time Requirements

Item	16mm Film	1" Tape	3/4" Tape	35mm Slides	35mm 1/2 Frame
Acquiring Materials-- Raw Stock	$108	$108	$ 76	$220	$110
Developing	$ 80	--	--	$198	$ 99
Filming and Taping (hours)	120	80	80	160	160
Editing (hours)	80	40	40	8	80

PREMASTERING FORMAT REQUIREMENTS WHEN DEVELOPING ORIGINAL AUDIOVISUAL MATERIALS FOR VIDEODISC

As videodisc technology becomes more available and as its application areas are expanded and broadened, more original training and educational materials will be developed and produced specifically for videodisc instruction. All such materials will be designed in the single or combined form of: (1) motion sequences, (2) still visuals, and/or (3) audio. Each of these forms can be further broken down into component parts, as shown in Figure 1.

Motion Sequences

Motion sequences can either originate from "live" motion produced by photographing movement as it occurs naturally or from animation produced by photographing positions of inanimate objects to achieve the illusion of movement.

Live Motion

Live motion sequences can be taken in real time by recording with a video camera at the tape speed rate of 30 frames/second or by photographing with motion picture camera at film speed rates of 24 frames/second for optical film and 18 frames/second for silent film. It is also possible to photograph at slower film speed rates (e.g., 10 frames/second). Once mastered on a videodisc, these motion sequences can give the appearance of

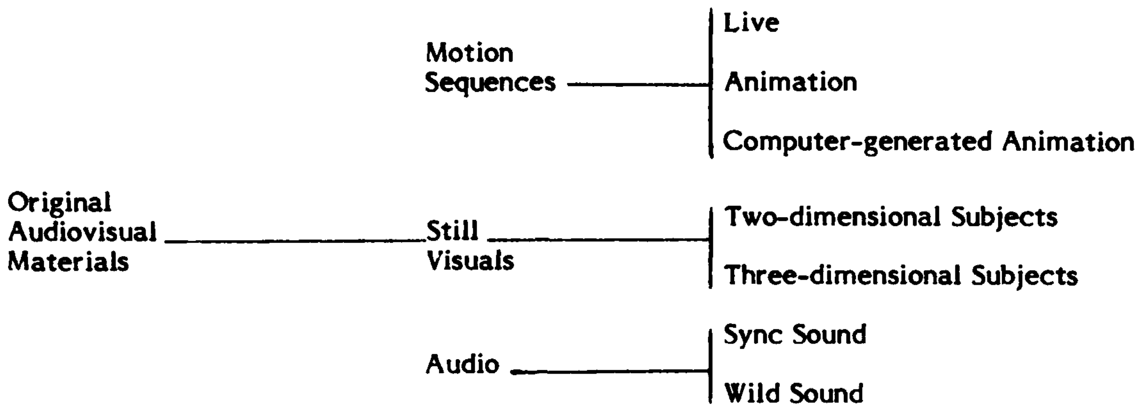

Figure 1. Forms of originally developed audiovisual materials.

standard motion if they are played back in slow motion. The major reason for photographing motion at 10 frames/second would be to save disc space, since the videodisc mastering process incorporates one frame/revolution. The difference in videodisc storage of film shot at 10 frames/second is three times less than for video tape (30 frames/second) (i.e., 1-1/2 hours versus 1/2 hour of motion).

The major disadvantage of using "live" motion sequences is that the natural occurring action must be carefully scripted, choreographed, acted, and/or enacted to capture the instructionally important events as they occur. Retakes of all or part of a motion sequence may be required to obtain the "desired" effect. In addition, editorial replacements, substitutions, and deletions may have to be performed before a satisfactory product is obtained for videodisc mastering. Under certain circumstances, a retake of an event may not be possible; under other circumstances, the event may not be reenactable in an exact replication of the original action.

Live motion sequences can be recorded with either a motion picture camera or a videocamera. Photography with a 16mm motion picture camera may be the most ideal method for the following reasons: (1) it yields excellent picture quality, (2) a wide selection of lens and film is available, (3) the film speed can be adjusted (including single frame shots), (4) 16mm motion picture film is the industrial standard, and (5) film can be converted to videotape without problems in loss of picture quality. The advantages of videotaping over filming are that (1) videotape allows for immediate playback and determination of whether the critical event has been successfully captured, and (2) editing procedures are easier and less expensive. One major disadvantage of videotape is that there is a loss in picture quality if it is transferred to film as a final premastering media. Another disadvantage in using videotape format for recording motion sequences for videodisc occurs when the student tries to step through the sequence in the freeze frame mode to study the details of a particular action or motion. In this situation, over half of the freeze frame displays will flutter, causing degradation of picture quality and resolution.

Animation

In contrast to "live" motion sequences, animation gives the illusion of natural motion. Animated motion is made by photographing successive positions of inanimate objects. The ideal method for producing animation is to use a device called an animation stand. This device is designed to hold either a 35mm or 16mm motion picture camera to film the subject, which is also held in a fixed position. The stand ensures correct and constant camera (film) to subject alignment for registration and focus. The use of video for recording original animation is not appropriate because of the problems of maintaining constant subject alignment and of the inability of video cameras to control the number of frames that are shot.

Computer-generated Animation

Computer-generated animation is a relatively new method of creating the illusion of motion. It can be done by successive position changes of computer graphics as they are displayed on a CRT monitor or on a plasma screen. A computer program is used to generate the graphics. By programming the time interval speed of the displays, photographing can be done as discrete single-frame shots or as motion shots. The ability to control film speed and adjust for low illumination levels of most computer graphic displays makes motion picture photography (e.g., 16mm film) an ideal premastering medium. The use of video to shoot computer-generated graphics may require the use of a special low illumination video camera.

Still Visuals

Still visuals consist of single frames on a film or tape. When mastered on a videodisc, still visuals are viewed with the step forward/reverse mode on the videodisc player. In terms of disc space, still visuals offer the greatest conservation of space--54,000 still visuals per side of a disc. From the standpoint of producing premastering formats of still visuals, different methods are typically used for two-dimensional and for three-dimensional subjects.

Two-dimensional Subjects

Two-dimensional subjects are flat objects, such as paper or animation cells containing drawings, text, pictures, or graphics. An animation cell is a heavy paper frame with 3-hole registration designed for placement into the 16/35mm animation stand. The subject is held behind the frame to ensure correct placement and registration for camera to subject alignment during photography. This method is essentially the same as that used during the steps of animation production. Again, the 16mm motion picture camera and film are the most ideally suited for this purpose: (1) 16mm film is an industrial standard for the animation stand, and (2) the 16mm camera is designed to allow single frame shooting.

Three-dimensional Subjects

Three-dimensional subjects are all objects that cannot be laid flat for use with the animation stand. The subject may be indoors or outdoors, still life, or live motion. The major problems of getting still visuals of three-dimensional subjects into a premastering format are focusing (camera/subject alignment), exposure (illumination), and timing (stop action). While the 16mm format may be suitable under certain conditions and situations, the best and most flexible format to use is the 35mm, full-frame, photographic camera and film. There is a wide variety of lenses and film types available to meet any demand, and the resulting prints and slides can be easily edited, selected, and transferred to either movie film or videotape.

Audio

This report will not discuss audio, except to say that both film and tape formats of motion sequences can accommodate the additional recording of sound. When audio is recorded live during the filming or taping, it is called "wild" sound. When it is produced after filming or taping, it is called "sync" sound. Motion picture film is unique, in that filming is done with "silent" film and then transferred to optical film to which the sound recording is added.

PREMASTERING FORMAT REQUIREMENTS WHEN CONVERTING EXISTING AUDIOVISUAL MATERIALS FOR VIDEODISC

A survey of the instructional audiovisual media formats used in Navy education and training shows that seven major types are currently employed:

1. Videotape--1 inch and 3/4 inch U
2. Filmstrip--8mm and 35mm
3. Training film--16mm and 8mm
4. Slides--35mm
5. Hard Copy--texts, study guides, workbooks, and manuals
6. Audio--reel-to-reel and cassette tapes
7. Computer-based Training--digital storage with CRT or plasma displays

In almost every Navy school, two or more of these formats are used. For example, in the Basic Electricity/Electronics School, the major instruction is (1) hard copy in the form of modularized study booklets, designed for individualized self-study and comprised of more than 2200 pages, and (2) enrichment materials that include sound-slide presentations, super 8mm and 16mm films, and tape recordings. Additionally, there are supplemental text materials, exceeding a total of 1000 pages. Before these materials could be converted into the storage medium (disc) and delivery system (player and display) offered by videodisc technology, they would have to be transferred into a single tape or film premastering format to meet the needs of the disc manufacturer.

Before converting existing audiovisual instructional materials for use with videodisc, a number of technical questions and problems must be considered and resolved, including the following:

1. What technical problems are encountered when transferring a variety of existing audiovisual media into a single film or tape format?

2. What display problems occur when existing audiovisual materials are transferred to a videodisc delivery system?

Existing Motion Picture Film

Transfer to Motion Picture Film

Existing motion picture film can be easily "print copied" into an identical format or dubbed up or down into a larger or smaller film format with relative ease and at a modest cost. When such film is then used as the premastering format for videodisc mastering, the resulting disc will exhibit a video display of excellent quality. The major problem of the display will be a loss at the corners and some edges of the original picture due to TV cut-off. Every disc frame will have good picture quality, if displayed in the freeze-frame mode.

Transfer to Tape

Existing motion picture film can be easily converted from its 24 frame/second format to that of the 30 frame/second videotape with a video film chain device called the telocine. The transfer procedure is not expensive. Videodiscs mastered from this videotape will have displays of good picture quality. There will be TV cut-off loss from the corners and edges of the original picture. Freeze framing of every disc frame will have good resolution, and there will be no flicker problems.

Existing Videotape

Transfer to Film

Videotape is transferred into a motion picture film format with a kinescope, a device that converts the 30-frame-per-second videotape format into a 24-frame-per-second optical film format. This type of transfer is expensive because of the cost of kinescopic equipment and availability of services to perform the work. In addition, picture quality is degraded as a result of the conversion, so a videodisc mastered from this format will display pictures of poor quality. Also, single frames displayed in freeze frame mode will also be difficult to view because of image flicker.

Transfer to Tape

An existing videotape can easily be duplicated into an identical format or dubbed up or down into a larger or smaller tape format. The cost is low, and a videodisc mastered from such a format will have good picture quality.

Existing Film Strip (35mm)

Transfer to Film

Existing 35mm film strip is comprised of single frame pictures and can be inexpensively dubbed down into 16mm optical or silent motion picture film. The 16mm film can then be used as the premastering format for videodisc mastering. Picture quality is maintained and the step frame of the videodisc player can capture and display the single pictures. The display will have TV cut-off loss, as well as a loss of the upper field border (due to sprocket lineup differences in photographic versus motion picture film in the copying equipment).

Transfer to Tape

Transfer of film strip to videotape is easily accomplished with a telocine. Videodisc displays derived from this format will have good quality with some TV cut-off loss.

Existing 35mm Slides

Transfer to Film

Existing 35mm slides can be transferred to 16mm motion picture film by two methods, both of which require rephotographing using the animation stand: (1) directly, using a CU lens, or (2) indirectly, by photographing 8 x 10 prints made from the slide. Each method adds another copy generation to the chain of obtaining a premastering format, and each generation will contribute to degradation in picture quality of the videodisc display. Both methods are expensive because of additional time required; the second method also involves the added cost of prints.

Transfer to Tape

There are two methods of transferring slides to videotape. The first method is indirect and involves taking 16mm motion picture film, onto which the slides have already been transferred, and then using a telocine for the conversion to tape. Again, another copy generation is added to the production chain to further degrade picture quality. This method is also expensive, due to the extra time required to make the transfer and the additional equipment and materials needed. The second method of transferring slides to tape uses a slide projector to project images into a television film-chain; this method is direct, easy, and inexpensive. Resulting picture displays have good resolution but some TV cut-off loss.

Existing Hard Copy

The transfer of hard copy in the form of text, drawings, pictures, photographs, or other two-dimensional subjects (CRT and plasma screen displays) into a tape or film format is confronted by two major problems. The first problem involves aspect-ratio differences between the dimensions of the hard copy and the frame size of film and tape. Both film and tape have a 4:3 aspect ratio, width to height respectively. This means that, if the size of the existing hard copy is different from a multiple of 4:3, part of the hard copy will be lost or a blank space will occur on the tape or film frame as a consequence of the transfer. For example, if an 8 x 10-inch photograph is placed at a distance to fill the width of a film frame, the bottom 4 inches of the photograph would be lost (Figure 2). If it is placed to fill the height of the film frame, the entire photograph will be captured, but 1-3/4 inches to the side of the frame (equivalent to 5-1/3 inches of the photograph) would be blank (Figure 3). The second problem is camera/subject distance, which affects resolution and readability of materials when they are televised. Camera/subject distance determines the size of the visual image recorded on the tape or film format, as well as the size and resolution of the image when it is televised from a premastering format. Figures 2 and 3 help to illustrate this phenomenon and also indicate a method for solving the problem of resolution; that is, to decrease the camera/subject distance, therefore enlarging the image size on the format frame (Figure 2 versus Figure 3). When all visual material on a single piece of hard copy is important, more than one frame may have to be used; when the hard copy contains a critical image that only occupies a portion of the materials, a single frame may be used.

Transfer to Film

Procedures for transferring hard copy to film premastering format have already been described. As with transfers to tape, aspect-ratio and camera/subject distance problems must still be resolved.

Transfer to Tape

Although it is easy and inexpensive to videotape hard copy with videocamera and recorder, the results are not very satisfactory. The videocamera cannot control the number of video frames that are taken when a single "page" of hard copy is recorded on tape. This real time shooting results in wasted tape, and it ultimately results in wasted videodisc storage space. The situation becomes more exaggerated when multiple shots are required to copy the "page" of hard copy in an attempt to compensate for aspect ratio or camera/subject distance problems. Furthermore, controlling the alignment of videocamera and hard copy to prevent a "keystoning effect" (subject appearing out of

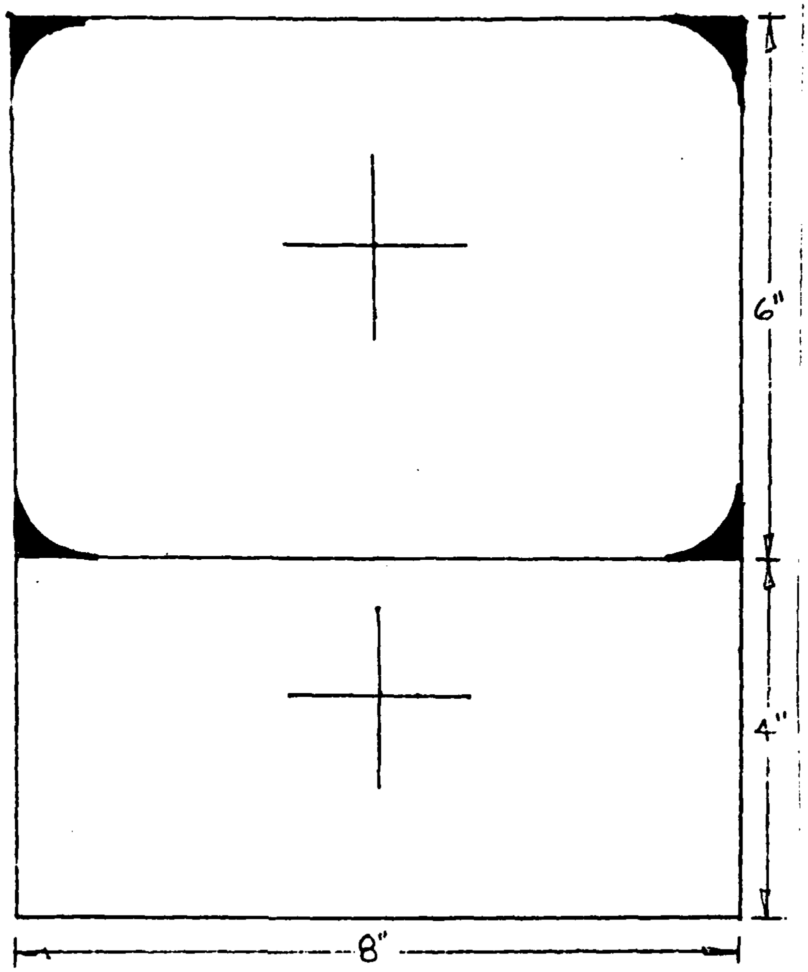

Figure 2. Result when 8 x 10-inch photograph is placed so that it fills width of a film frame.

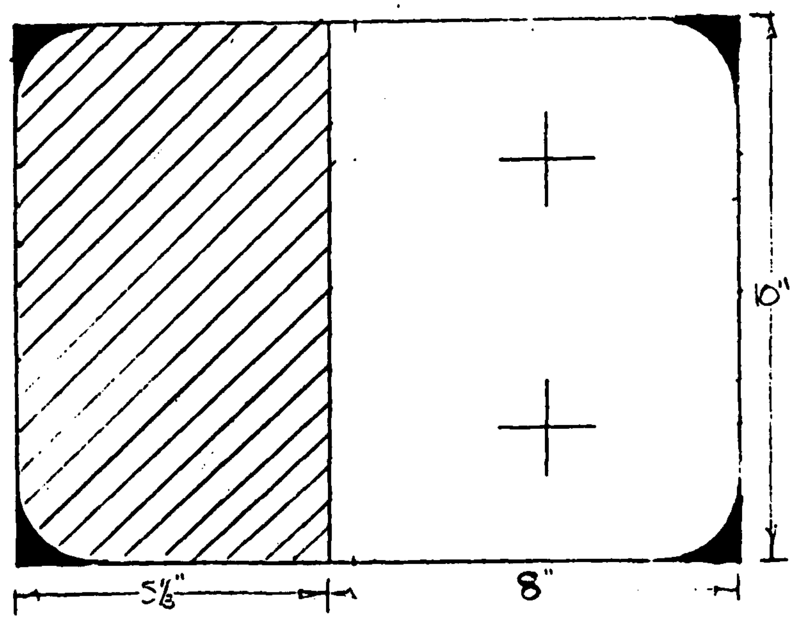

Figure 3. Result when 8 x 10-inch photograph is placed so that it fills the height of a film frame.

proportion or out of focus) is not possible. Finally, real time shooting makes it difficult to step quickly through videodisc displays in a freeze frame mode, because there are many video frames for each individual page of hard copy, as well as flicker problems.

Indirect methods of transferring hard copy to tape can produce satisfactory results. One procedure is to transfer the hard copy to film, either 35mm slides or 16mm motion picture film, using an animation stand to ensure good camera/subject alignment for focus. The film format is then transferred into a tape format as previously described in 35mm slide transfer to tape. While the additional transfer generation step can decrease picture resolution, as compared to a single step transfer, the advantages gained are freeze framing and stepping through to the next frame without display flicker and without wasted disc storage space.

DISCUSSION AND CONCLUSIONS

Videodisc technology appears to offer a new storage and retrieval capability for visual images that is superior to any other medium. The videodisc manufacturers require that source material for disc production be given to them on a single common premastering format--film or tape.

Little, if any, information is available about the advantages or disadvantages of the various formatting options. The videodisc manufacturer suggests that any existing audiovisual format can be converted to videodisc. Willis (1979) attempted to address the problem. Although details are omitted, it appears that a disc was eventually mastered from a variety of existing audiovisual instructional materials--35mm slides, 16mm and 8mm film, 3/4 inch U videocassette, and 2 inch videotape. Some of the film formats (35mm slides and 8mm film) were transferred to tape, and some film (35mm slides) was transferred to film (16mm), but no attempt was made to transfer tape to film. It was concluded that: (1) the quality of the various originating formats was acceptable, (2) the 3/4 inch U videocassette, as original format, flickers noticeably in the freeze-frame mode as predicted by videodisc manufacturers, and (3) the source material for the freeze-frame mode should be produced and/or supplied on film as the premastering format.

For premastering formats involving single images for use in the freeze-frame mode, one of the most important differences between source materials may be in the utilization of disc space. The use of 16mm film showed a large savings when compared to tape for the recording of single images. For example, when recording as few as 500 single images, 16mm film source required only 1/100th (.01) of one side of a videodisc for storage, whereas videotape required over two sides of a videodisc. Analytical investigation also discerned a number of advantages and disadvantages for use of film and of tape as premastering formats for videodisc. Whether the instructional materials are being newly developed or whether they already exist on film or tape also influences selection of formats.

Advantages and Disadvantages of Film

Some of the advantages of film (16mm) are:

1. Single frame recordings save disc space.

2. Single frame recordings allow for effective and efficient step-through mode.

3. Superior picture quality resolution and wide choice of film and lenses can be used to influence the subject, create special effects, and accommodate unique environmental conditions.

4. Film allows choice and flexibility in motion recording speeds: slow recording speed can save disc space by time compression using fewer frames, and ultranormal recording speed can be used to capture important motion sequences for study in freeze-frame mode.

5. Film is necessary for animation production, because it is the industrial standard for use in the animation stand that controls camera to subject alignment for registration and focus.

Some of the disadvantages of film (16mm) are:

1. Film development time produces a delay in feedback of recording results.

2. More personnel time is expended in filming and editing than with other formats.

3. Special care is required during filming in order to avoid loss of critical image areas caused by TV cut-off.

4. Film is a poor recipient for transfer from videotape.

Advantages and Disadvantages of Videotape

Videotape advantages are:

1. Immediate feedback of picture quality and content while taping.

2. Ease of editing and taping, a savings in personnel time.

3. Reusability of tape stock.

4. Capability to serve as a recipient for film transfer.

Some disadvantages of videotape are:

1. Inability to tape single frames directly; one frame of video for one frame of display is obtainable only by transfer from film.

2. Single speed taping of rapid motion may not capture visual detail sufficiently for freeze-frame study or without distortion by flicker.

3. Keystoning occurs when taping two-dimensional subjects.

Best Formats for Producing Original Materials

In almost every situation involving motion sequences and stills, 16mm motion picture film format is superior or equal to any other film or tape. It is equal to tape for motion, to 35mm slides for single images, and to 35mm motion picture film for animation.

Best Formats for Converting Existing Audiovisual Materials

Since there can be only one premastering format, all audiovisual materials must reside on either a single film or tape format. Because videotape does not transfer effectively to film, the presence of any existing audiovisual materials on videotape usually requires that the premastering format be videotape (i.e., if part of the existing materials are on tape, all other formats must also be transferred to tape).

Hard copy is the most difficult media to transfer to a premastering format. The two major reasons for this problem are (1) aspect-ratio differences between the size dimensions of the hard copy and the tape or film frame, and (2) subject-to-camera distance, which effects the size of the image when it is displayed by the videodisc. If the problems cannot be solved using multiple copies or enlargements of critical areas, then the hard copy must be revised. Again, as with original materials, 16mm motion picture film used in a single frame filming mode with an animation stand is the best format to use as the videodisc premastering format. It is equalled only by 35mm slides and 35mm film. If it is necessary to transfer the existing hard copy to videotape, the best approach is to first film the hard copy at an animation stand using film (16mm or 35mm) and then have the film transferred to tape.

RECOMMENDATIONS

1. Film formats should be used when recording single images and when producing animation.

2. If a mix of existing audiovisual materials is being converted for videodisc instruction, the presence of taped materials will dictate that all other formats be transferred into a videotape premastering format.

3. There are complex interactions between videodisc storage space, the quality of images displayed by videodisc, the size and resolution of videodisc images, and whether original or existing instructional materials are being developed. All of these variables should be carefully studied before selecting and using a particular premastering format.

REFERENCES

Crawford, A. M., Hurlock, R. E., Sassano, A., & Padilla, R. Part-task training using interactive computer graphics for simulation of operational equipment: A low cost training methodology for performance oriented skills (NPRDC Tech. Rep. 76TQ-46). San Diego: Navy Personnel Research and Development Center, September 1976. (AD-A029 540)

Fletcher, J. D. Video overview. Proceedings of the Annual Convention of the Association for the Development of Computer-Based Instructional Systems, Vol. I, San Diego, 27 February-1 March 1979.

Hawkins, W. W. Intelligent videodisc systems for military training: Authoring, program, and interface considerations. A paper read at American Educational Research Association, 1979 Annual Meeting, San Francisco, April 1979.

Hawkins, W. W., & Kribs, H. D. Technology for an effective delivery system (NAVTRAEQUIPCEN Tech. Rep. 78-C-0129). Orlando, FL: Navy Training Equipment Center, May 1979.

Hurlock, R. E., & Slough, D. A. Experimental evaluation of PLATO IV technology: Final report (NPRDC Tech. Rep. 76TQ-44). San Diego: Navy Personnel Research and Development Center, August 1976. (AD-A029 384)

Schneider, E. W. Videodiscs, or the individualization of instructional television. Educational technology, 1976, 16, 53-58.

Willis, B. D. Formats for the videodisc--what are the options? Educational and Industrial Television, 1979, 11, 36-38.