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ABSTRACT

If laser videodiscs are to become an important facet of computer-mediated education, cost-effective and time-effective methods of production must be found. Media Design Associates systematically investigated six ways to inexpensively transfer artwork to videodiscs. With each methodology, 204 pieces of varied artwork from the Biological Sciences Curriculum Study archives were transferred to a disc using various combinations of 35mm, and 16mm photography, and 1-inch videography. Analysis and evaluation of the resulting disc demonstrated that organizing the art was very important. Each of the six methodologies produced still frames with an acceptable range, but differences were discovered, and the best image quality and price and shortest time were accomplished using a state of the art video recorder capable of recording single video frames. Results indicate that quality still frames of artwork can be recorded on laser videodiscs at a reasonable cost for educational use. Cost effective pictures of real objects may now contribute to computer mediated educational experiences. A 24-item bibliography is included. (Author/LMM)

FINAL REPORT

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COMPUTER MEDIATED LASER VIDEODISC ART RETRIEVAL SYSTEM

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Boulder, Colorado 80302

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TABLE OF CONTENTS

FINAL REPORT

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U.S. Department of Education
SBIR Program Solicitation
RFP#84-022

Topic 2: Simplifying and Improving the Creation of Software
(Less Expensive Ways of Producing Videodiscs for Educational Uses)

COMPUTER MEDIATED LASER VIDEODISC ART RETRIEVAL SYSTEM

ABSTRACT

If laser videodiscs are to become an important facet of computer mediated education, cost and time effective methods of production must be found. Large collections of artwork with great educational potential have been expensive and time consuming to transfer to videodiscs.

Media Design Associates, Inc. of Boulder, Colorado systematically investigated six ways to inexpensively transfer artwork to videodiscs. With each methodology, 204 pieces of artwork from the Biological Sciences Curriculum Study archives were transferred to a disc using various combinations of 35 mm, 16 mm photography, and 1-inch videography. The resulting disc was analyzed and evaluated.

Organizing the art proved to be very important. Each of the six methodologies produced still frames with an acceptable range. However, differences were discovered. The best image quality, best price, and shortest time were accomplished using a state of the art video recorder capable of recording single video frames.

Results of the Phase I study indicate that it is feasible to record quality still frames of artwork onto laser videodiscs at a reasonable cost for educational use. Cost effective pictures of real things may now contribute to computer mediated educational experiences.

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INTRODUCTION

One of the most impressive features of laser videodiscs is the fact that a single side of an interactive disc can store 54,000 still images. As an educational device this means that two sides of a single disc can hold the equivalent of more than one thousand filmstrips, with an average of one hundred plus frames. Museum collections, data banks, catalogues of all types, reference materials, and slide libraries are a few of the many large collections of visuals being stored on discs. The visual quality of a well made disc is equal to or superior to print and photographic media. Disc collections lend themselves to interactive retrieval and certainly will find wide use in the educational systems of the future. (5, 20)

To transfer 54,000 still art pieces or photographs to a disc is not a simple task. Numbers alone are a problem. If one picture can be taken and transferred to tape each minute, 480 pictures can be transferred in an eight hour work day. In one hundred days, 48,000 pictures can be transferred. It will take about 113 days to transfer 54,000 still frames. That is more than half a year's work to transfer a single side of an interactive disc. If the pictures are being transferred using a CMX computer mediated video editing facility, costs can easily run $2,500 per day. Costs for a single side of a disc may be a quarter of a million dollars for transferring alone. Selection of pictures, organization, premastering, mastering, and replication still must be paid for. Photography (videography) and editing are usually conducted as separate steps, adding to the time and costs involved. It is little wonder that disc production has a reputation for being expensive. (8,24)

There are a number of methods by which still pictures, either art or photographs, may be transferred to tape and ultimately to videodisc. What is the best method for transferring art and/or photographs to a videodisc? What is the least expensive way to transfer stills? What method gives the highest quality picture? What is the most time efficient way to transfer artwork? These are the questions that Media Design Associates asked itself when contemplating videodisc production in 1983. In short, what is the least expensive way to get high quality still frames on a videodisc in a reasonable amount of time? MDA started asking these questions of disc producers already involved with still frame transfers. There were differences of opinion, and almost everyone MDA talked to felt their method was the best for accomplishing the task of storing still frames on discs.

It seemed to MDA that, while it might seem presumptive, someone should do a comparative evaluation of still frame techniques and further investigate ways of using still frame videodisc material in developing interactive microprocessed learning experiences. Most small private organizations do not have funds for such research even though the findings may provide significant product costs information. The National Institute of Education agreed that the subject was worthy of investigation and provided a Phase I contract of their SBIR program to initiate a study. The results of that investigation are the subject of this report.

Biological Sciences Curriculum Study Art Files

The Biological Sciences Curriculum Study (BSCS) has researched and developed hundreds of educational materials since its beginnings in 1958. Most of these materials include many of the finest biological illustrations ever produced. It has long been suggested that these illustrations could provide the basis of many fine educational experiences. Until the advent of the videodisc, this seemed to be an overwhelming task.

Thousands of illustrations of biological materials and other life sciences exist in the BSCS art archives. All rights to use this work have been reserved by the BSCS through copyright and publication agreements. For the purposes of this study these rights have been made available to MDA. All artwork reproduced by the study is part of the BSCS files. Various sized work in several different media were by design included in the study.

Once the major portion of the BSCS collection is transferred to videodisc these materials will become available in the form of computer mediated lessons. Several different kinds of computer-disc interactivity will be researched, tested, and evaluated during Phase II of the project. The program in Phase III will be expanded using private money as part of a computer-courseware educational series of materials. (23)

As a result of this project, the art materials held in the BSCS collection will become available to interested researchers such as artists and scientists. The collection has attracted the interest of many people but has been difficult to preview. The disc will serve as a review catalogue for such interests as exist. (19, 23)

The Problem

How can artwork be reproduced as single frames on a laser videodisc for the lowest possible cost, in a timely way, while maintaining a high degree of quality including linear resolution and color intensity?

METHODS OF PROCEDURES

In the original proposal for Phase I of this project, the following were identified as basic tasks:

1. Analyze the BSCS art files.
2. Select 200 pieces of artwork to be utilized in the study.
3. Complete photography (videography) for each of six methodologies.
4. Log data for each methodology.
5. Master a "model" disc.
6. Analyze the disc visuals.
7. Synthesize the results.
8. Publish the results.

In the first week of the project MDA staff members, working with BSCS staff members, analyzed the BSCS art archives located in the library of The Colorado College in Colorado Springs, Colorado. Two hundred two pieces of artwork were selected as subjects of the investigation. To these a color control card and a resolution chart were added, completing a test selection of two hundred four pieces of artwork.

The artwork was chosen from various projects covering a wide range of publications and visual aids. Various styles and techniques were included, such as:

1. Pencil sketches
2. Pen and ink drawings
3. Brush and ink drawings
4. Opaque black and white paintings
5. Opaque color paintings
6. Wash color paintings
7. PMT reproductions

Size and shape also varied. Sizes ranged from an animation field 4 to a field 17 (approximately 4" to 20" wide). One hundred and forty-eight visuals were prepared for animation photography using punched registration. This represents about three-quarters of the selected visuals. Fifty-six illustrations were not registered for copying. For various reasons they did not lend themselves to animation punching. They were either too large, or too thick, or too awkward for punching.

Only artwork was evaluated in this investigation. Photographs and printed material were omitted in the experimental design. These materials would have increased the variables and complicated the final results.

Methodologies Evaluated

In order to produce individual still frames on a videodisc the images must first be transferred to a 1-inch or 3/4-inch premaster tape. The 1-inch tape is preferred, as it results in the best pictures. Rigid techr.cal specifications must be met in order to produce a disc with quality still frame capability.

On an interactive CAV (Constant Angular Velocity) disc, the linear program on one side of the disc may run from 0 to 30 minutes. The premaster tape must have a continuous and increasing SMPTE Time Code. Each video fram has two picture components called fields. If still frame acquisition is to be used, one of these fields must be dominant throughout a single disc or the resulting picture will vibrate or flicker. Either 1-inch type C composite NTSC 525-line 60 Hz, or 3/4-inch professional NTSC 525-line 60 Hz tape may be used for premastering. Many quality video facilities do not have the capability of producing master materials for the development of interactive videodiscs. Specifications for discs are provided by Pioneer, Sony, and 3-M. (1, 18, 24)

All two hundred four pieces of art were transferred to 1-inch videotape and later to a laser videodisc using six methodologies that offered a cost effective way of transferring still material to disc. Several other methods were examined and not incorporated into the study because they are not cost effective for large art collections. For the most part, these methods involve extensive video editing which is expensive and time consuming. This report later discusses the findings involving some of these technologies.

It is often advantageous to convert an art archive to 35 mm transparency slides prior to transferring a collection. It may be that the collection cannot be moved to a video or film animation facility. It may be that editing and/or organizing of the collection is required prior to transfer. Whatever the reason, 35 mm transparencies are often used as source materials prior to transfer to premastered tape and ultimately to laser videodisc.

Transferring to motion picture film is also a common practice prior to videotaping. Transfers to videotape from film must be done at 30 frames/second. This is the video standard used in this country. To transfer at other film speeds, such as 24 frames/second, will cause field problems on the resulting tape. This will result in unsteady frames in the video. (4, 9)

All two hundred four video frames were transferred using the following methodologies and systematically compared on the resulting video disc:

1. Artwork to 35 mm motion picture film to 1-inch video to disc.
2. Artwork to 16 mm motion picture film to 1-inch video to disc.

3. **Artwork to 35 mm transparencies to 35 mm motion picture film to 1-inch video to disc.**
4. **Artwork to 35 mm transparencies to 16 mm motion picture film to 1-inch video to disc.**
5. **Artwork directly to 1-inch video to disc.**
6. **Artwork to 35 mm slides to 1-inch video to disc.**

Methods Compared - Procedures*

1. **Artwork to 35 mm Motion Picture Film -**

All of the artwork including the color and resolution frames were transferred from the flat art to 35 mm motion picture film in a single frame format similar to that used for 35 mm filmstrips. The film was processed and encoded on 1-inch videotape using a Rank Cintel Flying Spot Telecine scanner.

35 mm animation photography was completed at Stan Phillips and Associates in Denver, Colorado. A 35 mm Acme camera with 120° shutter using a Pentax Macro lens mounted on an Oxberry animation stand was used. A CBM 2001 Series Commodore Control Computer managed exposure and distance.

Frames 1-100 were photographed using FUJI 8511 negative film with an ASA rating of 100. Frames 101-204 were photographed using Eastman Kodak negative film ECN 5247 with an ASA rating of 125.

The negative film was processed at Western Cine Laboratories in Denver and printed on positive 35 mm workprint stock. No retakes of this method were required.

Rank Cintel transfer to 1-inch videotape at 30 frames/second was made at WickerWorks in Denver. Color correction was possible at this stage but was not required beyond a single overall adjustment.

The Acme animation camera usually requires pin registered subject material as it has no direct viewing system while photographing art. Focus and exposure are managed by computer. The unregistered 55 frames of the test materials required centering but presented no real problems in photographing. Changing distance with the Oxberry stand proved to be extremely time consuming. Moving from a field 8 to a field 17 took over four minutes.

The videotape of the 35 mm transfer was CMX edited into a premastered 1-inch tape at Realtime Video Productions in San Francisco, California.

* See Figure 1, Page 9.

2. **Artwork to 16 mm Motion Picture Film -**

All of the artwork was photographed as 16 mm single frames by West Wind Productions of Boulder, Colorado. This was similar to the 35 mm photography of the original art.

Single 16 mm frames were photographed using a Bell and Howell 70-DL camera adapted for still framing. The camera was equipped with a Bausch and Lomb 25 mm lens.

Eastman Kodak Commercial Ektachrome 7252 was used as original film stock. This is a reversal film and was not work printed. 3200°K incandescent lighting was used to light the artwork. Retakes were not required nor was video editing. (16)

The resulting footage was edited into a timed format master of the completed program. This master provided a film frame for each videodisc frame required in the completed program. Blanks were left where later CMX edited video sequences would be placed. This format master was completed in 16 mm and transferred at 30/second using the Rank Cintel Telecine at WickerWorks in Denver.

The original film in 16 mm required an overall color and density enhancement by the Rank Cintel. Individual frames did not require correction. All film was processed by Western Cine of Denver. The entire format master including the art frame sequences became the basis for the final edit at Realtime Video in San Francisco, California. (1)

3. **Artwork to 35 mm Transparencies to 35 mm Motion Picture Film -**

All of the artwork was photographed using a Nikon F-2 camera and a Nikor macro lens. The camera equipment was locked down using a Miller head tripod and a Cine-60 locking device. Pin registration was used for frames 1-148. The remaining art was centered for copying. All of the artwork was photographed using Kodachrome 64 film rated at ASA 64 with open shade daylight lighting. The artwork was rephotographed using Ektachrome 140 film rated at ASA 140 with 3200° K incandescent lamps for lighting. The best resulting slide transparencies were picked for transfer. Kodachrome and Ektachrome were about equally represented in the final selection. The same 204 slides were rephotographed first in 35 mm, then in 16 mm, and finally were videographed directly onto 1-inch tape. All of the original 35 mm transparency film was processed by Eastman Kodak.

A 35 mm slide transparency has a proportional aspect ratio of 3 x 2. This becomes an important factor when transferring slide transparencies to motion picture film or videotape, both of which have a 4 x 3 proportional aspect ratio. A considerable part of the sides of a slide image is lost when transferred to motion picture film or video. About 1/8 of the picture area is lost on the sides of the transferred frame. This must be taken into account if transparencies are to intermediate art to video transfers.*

The transparencies to be transferred were numbered in sequence with colored tabs. The same orientation for the numbering was used to simplify and expedite the transfers.

The slides were photographed at Stan Phillips Associates of Denver using an Acme animation camera. An Oxberry image expander was used in projecting the slides. This system uses a transparent mirror system that projects the slide image on a flat surface while permitting photography through a two-way mirror. The image size is a 12 TV field or a 9 animation field.

Both FUJI 8511 and Eastman ECN 5247 were used to photograph the projected transparency images. The film was processed by Western Cine of Denver. The transparencies were photographed three times using this system because of technical problems with the first two attempts. The negative film was workprinted for review.

The negative was transferred at WickerWorks in Denver and required a single video edit. The resulting 1-inch tape was later edited into the premaster tape at Realtime in San Francisco.

4. Artwork to 35 mm Transparencies to 16 mm Motion Picture Film -

West Wind Productions of Boulder, Colorado transferred the transparency slides to 16 mm film. A Bell and Howell 70 DL with a 25 mm Bausch and Lomb lens was used. The camera wes mounted on a Miller tripod with a Cine-60 snaplock. The transparencies were projected with a Kodak Carousel projector on a rear screen by Daylight. The projector bulb was rated at 3500°K.

Eastman Kodak Commercial Ektachrome 3252 was used as a film stock rated at 3200°K. Film was processed by Western Cine of Denver. The original film was edited into the master film prior to transfer. Extensive film tape editing was done on the art frames. These materials were transferred by WickerWorks in Denver. Color and density correction were made with the Rank Cintel using an AMIGO computer system. Jumps in the original single tape splices were corrected using double tape splices. The entire transparency collection was photographed several times to evaluate various exposures and techniques.

5. Artwork to 1-inch Videotape Directly -

Originally the MDA research plan called for transferring single frame art material directly to video by taking a short video sequence (video burst) and then single frame editing. This would, in time, lay down all of the art frames in the order desired. This method has been a very common way of transferring art frames or other still material to a laser videodisc. It is an expensive way to

* See Figure #2, Page 12.

transfer still material, however. The tasks are not difficult but the time involved with the video edits destroys the cost and time effectiveness if the material to be transferred is at all extensive. To do sixty single frame edits per hour would, in MDA's best judgment, be extremely fast. Twenty to thirty edits per hour is a more reasonable expectation. Checking prices around the country for this kind of transfer, including both videography and editing, MDA found firm quotes from $15/frame all the way up to $285/frame. Little wonder that videodisc production is getting a reputation as being expensive.

Until very recently it was not possible to record single frames directly using a 1-inch video recorder. Such a recorder, the Sony BVH-2500, became available in the late spring of 1984. It can be used for editing single frames but, more importantly, it can take single frames from a video camera and record these on tape.

The first BVH-2500 was delivered to Realtime Video Productions in San Francisco. As premastering facilities are not available in the Rocky Mountain region, MDA arranged to have final edits and mastering completed at Realtime. Video transfers were made from the flat art and later from the 35 mm transparencies.

In addition to the BVH-2500, Realtime's video editing facility features two BVH-2000s, a CMX 340X editor, and a Grass Valley Switcher with E-MEM. The camera used to videograph the art was a Sony 330. Images were laid down on the master tape with maximum pitch, helping to enhance the video image in the resulting disc. Cost for the transfer was a contract $1/frame. Editing of all the technologies was also completed at Realtime.

MDA experimented with several other video recording, editing, and transfer methods. These included the video burst method and single frame edit, as mentioned above. Telecine single frame transfers using a Rank Cintel were also used. While most of these systems work well, they are generally too costly and too time consuming. (2, 5, 8)

6. Artwork to 35 mm Transparencies to Video –

The 35 mm slide transparencies were also videographed at Realtime Video Productions using a Sony 330 camera and the single frame capability of the BVH 2500.

A projected image of each slide was videographed and transferred to 1-inch tape. This ultimately was video edited into the master tape.

Cost for the slide transparency transfer was contracted at $1/slide. Cost of the individual 35 mm slide transparencies was about 50¢. This does not include photographic time for the transparencies. The transparencies were mounted in carousel trays prior to transfer. Actual transfer time for the 204 images was about one hour. Mounting the slides took perhaps twenty minutes and another ten to empty the trays, replacing the transparencies in their storage boxes.

TECHNOLOGICAL STEPS (GENERATIONS)
FROM ORIGINAL ART TO VIDEODISC

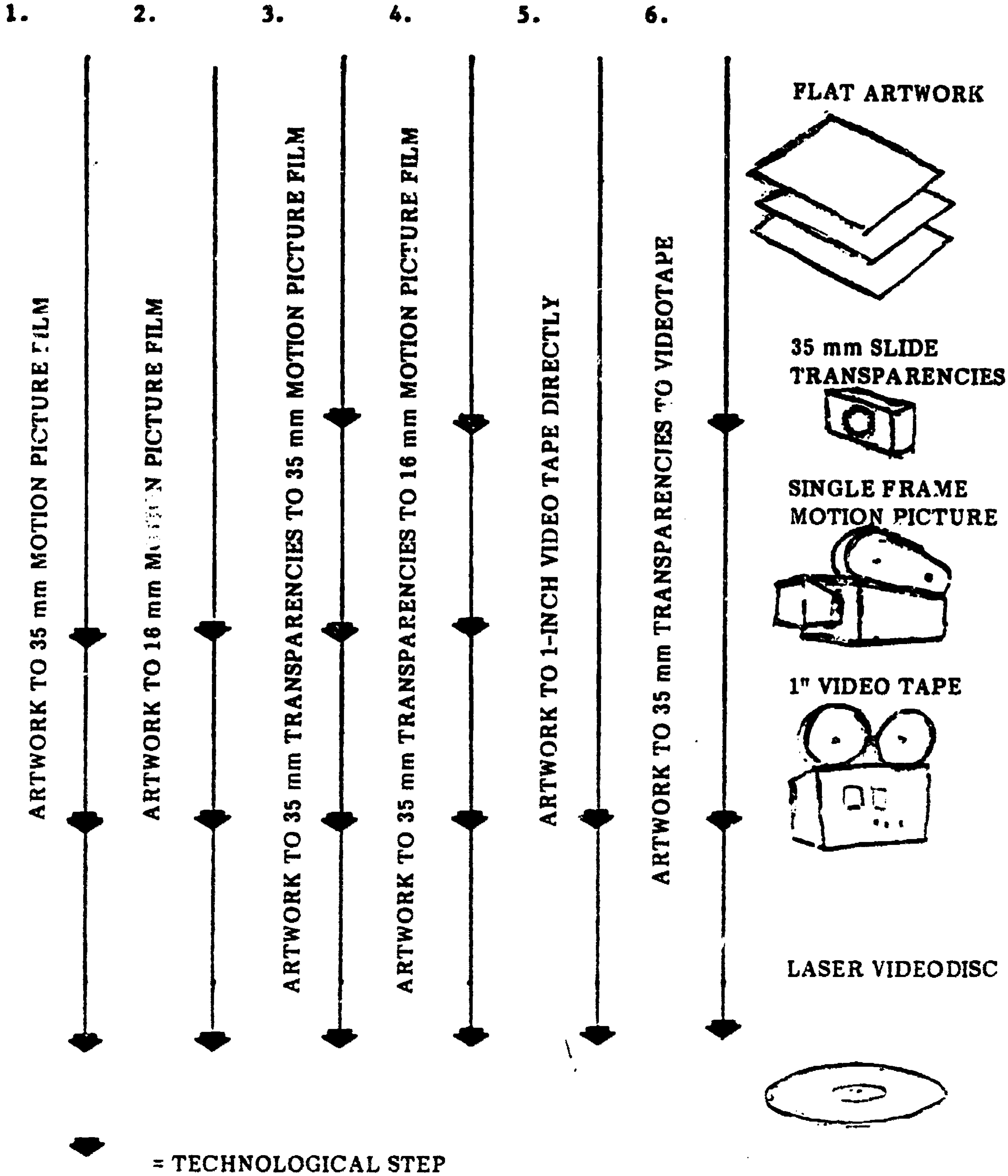

FIGURE #1

Premastering of the Disc

The Art Retrieval Laser Videodisc was premastered at Realtime Video Productions in San Francisco. Realtime came to MDA's attention through a number of journal articles. They have facilities, equipment, and staff specialized for disc transfer.

Realtime transferred the artwork using the two video methodologies used in the project. They also CMX edited the other four methodologies along with the continuity materials used in the completed videodisc. A master 1-inch tape and computer mediated time code read out were the results of the premastering session.

Disc Analysis

The master 1-inch video tape was sent to Spectra Image in Burbank, California for the mastering of the completed disc. The first completed disc was received at the MDA offices in Boulder and reviewed by the MDA staff. Art directors responsible for the original BSCS art responded to the disc—commenting on quality and reproduction of the 1200 plus images.

Resolution and chroma level for each technology were measured and compared. Subjective as well as objective comparisons were made. The various technologies, film stocks, and transfer methods were compared.

In addition to evaluating the methodologies, costs and time were analyzed and compared. Various art techniques were evaluated for their potential as source materials for laser videodisc display.

Dissemination

Dissemination of information concerning the project has been undertaken by MDA. About halfway through Phase I a news release was sent out to a variety of media and educational journals. MDA has received a number of requests for the final report, which will be sent to interested parties. The BSCS newsletter carried a report on the project.

Charles Tepfer, editor and publisher of EITV—the Techniques Magazine for Professional Video—has requested two articles concerning the project. The first article, written by Norris Ross, was sent to Mr. Tepfer for publication early in 1985. The second article will include the results of the Phase I study and a report on plans for the Phase II part of the project.

Technological Horizons in Education (T.H.E. Journal) has requested an article concerning MDA's findings on single frame access from laser videodiscs. Other articles are anticipated for both science education publications and video journals. Only limited copies of the experimental disc exist at this time. These are available for review at the MDA offices in Boulder. As Phase II begins, additional copies will become available so that they may be circulated to educators and disc publishers around the country.

Papers and presentations of the disc will be given at a variety of professional meetings during the coming year. These include both technical gatherings and educational programs.

RESULTS

Format Problems

The format ratio of a television or video image is absolutely fixed at 4 x 3. This makes it very difficult to use many pieces of artwork for video purposes. Flat art intended for print publication does not have these limits. A drawing that is taller than it is wide presents no problem when being printed, but it does not fit a video format very well at all.

One answer to this is to place a matte around the artwork, creating the 4x3 aspects of a video image. The matte may be placed over the artwork much like a matte for a painting. Some video facilities can matte the images electronically. Color may be added or subtracted using special video devices. A plain background, white, black, or even colored, can be used to frame the artwork.

While there are solutions to the format problem, they must be handled, and it can take a considerable amount of time to do so.

A second format problem is common to all video. A large part of a video image is lost to view, being cut off by the border around the television image. This is known as TV cut-off. The center portion of the picture is known as the safe area. This problem becomes worse when 35 mm transparency slides are transferred to a video image; 35 mm transparencies are proportionally wider than a film or video image. (16)

VIDEO FORMAT

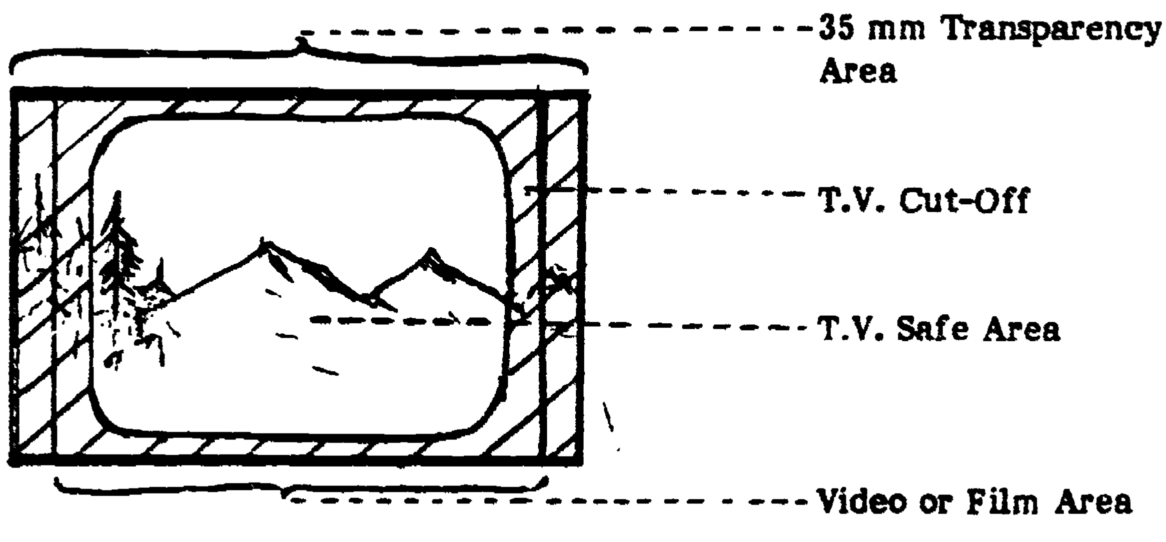

FIGURE #2

Images Compared

All of the methodologies tested and evaluated in this study produced images that were within an acceptable range. MDA did the best it could with each methodology. The resulting images from each method could be improved if attempted in the future. Quality equipment and materials were used throughout the project. If different equipment and/or different materials were used, the results might be affected but would approximate those obtained here. Any of the techniques used can do a quality job of producing still frames for videodisc storage.

Color intensity in video is measured by chroma level, or chromance. One hundred percent chromance is very intense. The two methods using 35 mm motion picture film resulted in chroma levels that were quite high: the direct photography of the art approached 100 percent chromance, and the transparency photography had a chroma level of 80 percent. This may be in part because the film was transferred at 100 percent by the Rank Cintel. The 16 mm transfers were not nearly as intense, although they were transferred at the same time as the 35 mm film. Chromance in each 16 mm method was 65 percent. Chroma levels for the two 1-inch video transfers were 75 percent. This may have been a subjective reaction by the video engineer. The colors in all technologies look good, even though the lower levels tend to look pastel.

The 35 mm transparencies on the resulting disc showed differences. The Kodachrome slides displayed a bluish hue while the Ektachrome slides were reddish. This was apparent in both the 35 mm and the 16 mm film methodologies. The video transfer of the 35 mm transparencies balanced the color from frame to frame more equally, and the differences between the Kodachrome and Ektachrome were not obvious. The tungsten light source may have shifted slightly toward the red.

In the 35 mm motion picture photography of the artwork, the first 100 frames were photographed on Fuji negative and the next 104 were photographed on Eastman Kodak negative. Both had the same processing. The Fuji color had a definite blue cast; the Eastman film had a more balanced color rendition. These colors were present in the positive workprint and later were evident in the transferred videotape and disc.

Resolution

Resolving power is affected by a variety of factors, the number of generations from the original and the equipment used being perhaps the most important factors. Resolution can be measured by the number of lines that can be reproduced over a given distance. For the tests made in this evaluation the number of lines in an inch were measured.

The 35 mm flat motion picture art method reproduced 133 lines per inch. The 35 mm methodology using the transparencies reproduced 93 lines per inch. The 16 mm photography of the flat art produced 78 lines per inch, and the 16 mm photography of the transparencies resulted in reproducing 93 lines per inch. The direct video transfers of the art produced a resolution of 133 lines per inch. The video transfer of the 35 mm transparencies produced 111 lines per inch.

Resolution is usually measured for a single element of a system, such as a lens. In the case of this project, the whole system used to reproduce the art was measured and evaluated.

Sharpness is related to the edges of an image. This is affected by the resolution or resolving power and by several other factors. Different colors produce different edge effects where they meet. Contrast is a factor. A bright area next to a dark area is sharper than the edge between two neutral tones. Sharpness can be a very elusive specification. Light quality (the difference between light and dark), acuteness (density of light at a given point), and definition (the focus of a point) all affect sharpness. The 35 mm transfer of the flat art and the video direct transfer of the flat art proved to be the sharpest of the six technologies evaluated.

Lenses, cameras, recorders, film, and tape all affect the quality of the final image. In each generation—that is, each time an image is transferred—there is some loss of picture quality, although it may be hard to measure.

Much of the evaluation of a picture, be it artwork, photography, or video, is subjective. What looks good? Not everyone sees a picture in the same way, and different people like different things. MDA values the inputs that it has had from many different people concerning the quality of the various 1200 plus individual videodisc images that are the result of the study.

All sizes of artwork photographed and videographed well and presented few problems. Several large illustrations have small type; the type became difficult or impossible to read when transferred to a video image. The larger and bolder type styles are superior in readability. Likewise, the various media used for the art produced few video transfer problems. A number of people remarked that in many cases the art looked better on video than in its original state before being reproduced.

Costs of Single Frame Transfers

The costs for the technical transfers of the individual still frames ranged from $1.18 to $1.92. This included cost of equipment rental, facilities and lab costs, as well as film and tape materials. It does not cover the costs of transportation or the costs of preparing the original artwork for reproduction. Costs per frame were as follows:

Video direct of artwork	$1.18/frame
16 mm copy of transparencies	1.45/frame
16 mm copy of artwork	1.48/frame

Video copy of transparencies	1.80/frame
35 mm copy of artwork	1.89/frame
35 mm copy of transparencies	1.92/frame

Time to Transfer Each Art Piece

The time required to transfer the organized artwork to the final premaster tape was kept. This included the time to photograph the 35 mm transparencies. Time involved was as follows:

Video direct of artwork.................	1.47 minutes/frame
16 mm copy of artwork.................	1.91 minutes/frame
16 mm copy of transparencies	1.96 minutes/frame
35 mm copy of artwork.................	2.06 minutes/frame
Video copy of transparencies	2.06 minutes/frame
35 mm copy of transparencies	2.35 minutes/frame

Time involved to transfer larger collections might be longer or shorter than the above results indicate. It could well be that as operators gained experience the events would take place at a more rapid pace.

Having the artwork well organized and ready to transfer can definitely cut costs and time. Artwork should be arranged by subject and size. If animation equipment is used, the art should be punched or have a punched strip attached in order to register the material for photography or videography. One hundred forty-nine of the project's art pieces were punched. The remainder were not punched. In the direct video transfers this caused no problem. In the film animation technologies great care must be taken to center the art, as most animation cameras do not provide through-the-lens viewing.

Methodologies Compared

	Transfer Time/Frame	Cost/ Frame	Resolution Lines/Inch	Chroma Level
1. Artwork to 35 mm film to video	2.06 min	$1.89	133	100%
2. Artwork to 16 mm film to video	1.91 min	1.48	78	80
3. Artwork to transparencies to 35 mm film to video	2.35 min	1.92	93	65
4. Artwork to transparencies to 16 mm film to video	1.96 min	1.45	93	65
5. Art to video	1.47 min	1.18	133	75
6. Artwork to transparencies to video	2.06 min	1.80	111	75

CONCLUSIONS

Media Design Associates undertook this project to investigate cost effective ways that single frames of artwork can be transferred to laser videodisc for ultimate use in computer mediated educational programs. The following conclusions and recommendations are supported by the findings of this study:

1. All artwork must be organized and decisions concerning formatting must be made prior to photography or videography of the art.

2. Most artwork will lend itself to laser videodisc transfer and display.

3. Cost per frame can be less than $2 each.

4. The brightest color may best be achieved with the use of large format photography such as 35 mm animation.

5. The best price can be obtained by direct single frame video transfer using single frame video recorders. The advent of such equipment is very recent.

6. The fastest way to transfer art to discs is by direct single frame video transfer.

7. Good color and definition may be obtained by carefully using any one of several technologies.

8. The best and least expensive procedure to follow when transferring artwork to single frame laser videodisc storage is to move the art collection to a CMX video editing facility with a still frame 1-inch recorder.

9. If the art collection cannot be moved and the artwork must first be photographed as 35 mm transparencies, either a video or a 35 mm motion picture transfer to videotape and then disc may be made. The video methodology is slightly more cost and time effective.

10. If the number of still frames to be placed on a disc is small, circumstances may justify using equipment and facilities at hand. If, on the other hand, the collection to be transferred is relatively large, significant savings in time and money may be made by using the most direct premastering methodology available.

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GLOSSARY OF TERMS

Address - Location on tape or disc. On CAV Laser Videodisc this is usually a frame number.

Balance (Video White Balance) - Equal levels in the red, blue, and green signals which produce a neutral gray scale from black to white.

CAI - Computer Assisted Instruction.

CAV - Constant Angular Velocity—a laser videodisc that revolves at 1800 rpm, or frames per minute. This permits access to single frames. Contains up to 54,000 frames.

CLV - Constant Linear Velocity—videodisc that will only run at 30 frames/second. Still frames are not possible. Contains up to 108,000 frames.

Chroma Level (Chromance) - Color saturation. Low chroma level produces pastel, washed-out color. High chroma level produces heavy saturated colors.

CMX Editing - Video editing under computer mediation—may include insert editing and/or assembly editing. "CMX" is a brand name.

Courseware - Teaching software—may include tapes (sound or video), computer programs, films, books, and videodiscs.

Field Dominance - A video recording where either field 1 or field 2 of all video frames is dominant.

Flicker - Inter-field disparity in a single video frame.

Flying Spot Scanner Telecine - A device for the transfer of motion picture film or slide transparencies to a video signal.

Freeze Frame - To stop a given frame in a still mode during use of a videotape or videodisc.

Hardware - Machine required to manage a program.

Interactivity - Program material and presentation that respond to the inputs and reactions of the viewer.

Level - In video, measurement of a video signal voltage relative to either flanking or sync. A low signal level indicates low brightness and contrast.

Mastering - Encoding master disc from master videotape.

Menu – Table of Contents.

Negative Original – Camera film that is processed to produce a negative image.

Off-Line – Any operation not under the control of the computer, occuring independently.

On-Line – Any operation under computer control.

Premastering – the post production of a master videotape with technical requirements for a resulting videodisc.

Random Access – Access to a video address at any time.

Resolution – Subjectively apparent as sharpness. The ability of a system to reproduce fine detail and sharp edges.

Reversal Original – Camera film that is processed to produce a positive image.

SMPTE Time Code – A digital location code placed on videotape.

Still Frame – A single frame placed in a film or video program with intent or purpose.

APPENDIX

Description of the Art as Transferred

Cost Factors

Time Factors

DESCRIPTION OF THE ART AS TRANSFERRED - ART RETRIEVAL SYSTEM

1.	Basic Color Chart	10x8	
2.	Resolution Chart	10x8	
3.	Chick & Egg	3x2	Pencil
4.	Lizard	5x4	PMT
5.	Two Lizards	4x2½	PMT
6.	Corn	5x3½	Opaque Color
7.	Cabbage	5x3½	Opaque Color
8.	Spinach	5x3½	Opaque Color
9.	Peas	5x3½	Opaque Color
10.	Beet	5x3½	Opaque Color
11.	Celery	5x3½	Opaque Color
12.	Turnip	5x3½	Opaque Color
13.	Asparagus	5x3½	Opaque Color
14.	Walnuts	5x3½	Opaque Color
15.	Lettuce	5x3½	Opaque Color
16.	Mouth & Tongue	6½x5½	Pencil
17.	Three Chimpanzees	5½x4	Pen and Ink
18.	Chimpanzee in Tree	6x5	Pen and Ink
19.	Frog Skeleton	7x4	Pen and Ink
20.	Dinosaur Skeleton	6x4	Pen and Ink
21.	Platy X Swordtail Hybrids	7x5	PMT
22.	Test Tubes	5x3½	PMT
23.	Cartoon - Shoe & Kids	5x5	PMT
24.	Uterus - Two Views	6x3½	PMT
25.	Various Sperm Examples	7x4	PMT
26.	Bacteria Energy Chart	5½x4	PMT
27.	Cell Parts	7x4½	PMT
28.	Section of Uterus	6½x4	PMT
29.	Vertebrae	5x4	Opaque Black & White
30.	Experimental Jars	6x4	Opaque Black & White
31.	Chimpanzee	8x5	Opaque Color
32.	Chicken Thigh	5x3½	Opaque Color
33.	Lamb Chop	5x3½	Opaque Color
34.	Chicken Wing	5x3½	Opaque Color
35.	Pork Chop	5x3½	Opaque Color
36.	Beef Roast	6x4½	Opaque Color
37.	Fish Fillet	6½x3½	Opaque Color
38.	Chicken Drumstick	6½x3½	Opaque Color
39.	Bacon	6½x5	Opaque Color
40.	Beef Steak	6x4	Opaque Color
41.	Ham	4½x4½	Opaque Color
42.	Fish Steak	5½x4	Opaque Color
43.	Lamb Leg	6x4	Opaque Color
44.	Hamburger	5x4½	Opaque Color

45.	Sardines	6x4	Opaque Color
46.	Eye with Lid	8x6	Pencil
47.	Scientist in Lab	7½x5	Pencil
48.	Girl in Forest	6½x6	Pen and Ink
49.	Agar Dish	6½x4	Pen and Ink
50.	Leaf Samples	6½x4½	PMT
51.	Culture Dish	7x4½	Pen and Ink
52.	Sea Coast	8x8	Opaque Black & White
53.	Girl & Jungle Camp	9x7	Opaque Color
54.	Krill & Penguins	8x4	Opaque Black & White
55.	Skull	7x6	Opaque Black & White
56.	Skull	7x7	Opaque Black & White
57.	Skull	7x6	Opaque Black & White
58.	Corn Shoot Experiment	7x6	Pen and Ink
59.	Corn Shoots	7x4	PMT
60.	Young Chimps	6½x5	Pen and Ink
61.	Girl by Fire	8x5	Pen and Ink
62.	Fetus Development	6x6	PMT
63.	Mouse Experiment	6½x5½	PMT
64.	Oak Tree	8x4½	Pencil
65.	Leaf Types	6½x6	Pencil
66.	Chimpanzee	7½x8	Opaque Color
67.	Art Chart	8x6	Pencil
68.	Dog Chart	7½x6	Pen and Ink
69.	Rat Test	9x5½	Pen and Ink
70.	Spore Cases	9x6	PMT
71.	Navajo Chart	10x8	PMT
72.	Plant Types	9½x3	Pen and Ink with PMT
73.	Insect Case	7x3	Pen and Ink
74.	Insect Eggs	7x6	Pen and Ink
75.	Skeletons	9x6	PMT
76.	Grasshopper	9x5	Pen and Ink
77.	Soil Experiment	9x7½	Pen and Ink
78.	Beetle	9x5	Pen and Ink
79.	Girl and Tent	7x7	Pen and Ink
80.	Ape and Termite	7x7	Pen and Ink
81.	Doe and Fawn Deer	9x10	PMT
82.	Kidney Cross-Section	8x6	PMT
83.	Egg Release	8x6	PMT
84.	Stem Cross-Section	10x6	PMT
85.	Skull	7x7	Opaque Black & White
86.	Arm with Joints	9x6	Opaque Black & White
87.	Male Reproduction System	10x4½	Opaque Black & White
88.	Worm Waste Organs	10x4	Opaque Black & White
89.	Snails	11x8	Opaque Black & White
90.	Skin Cross-Section	8x8	Opaque Black & White
91.	HMS Beagle	9x7	Opaque Black & White

92.	Cricket	16x8	Opaque Black & White
93.	Fish	16x7	Opaque Black & White
94.	Man and Fish	7x8	Opaque Color
95.	Glyptodont	13x6	Opaque Color
96.	Banded Ant Eater	9x6	Opaque Color
97.	Marsupial Mole	9x7	Opaque Color
98.	Marsupial Mice	9x7	Opaque Color
99.	Oyster Drill	11x8	Opaque Color
100.	Tasmanian Wolf	11x8	Opaque Color
101.	Honey Marsupial	11x8	Opaque Color
102.	Rat Kangaroo	11x8	Opaque Color
103.	Chicken Little	11x8	Opaque Color
104.	Coleoptiles	12x8	Opaque Color
105.	Lungs	11x8	Opaque Color
106.	Nose	12x10	Acetate Overlay
107.	Diaphram	12x10	Acetate Overlay
108.	Windpipe	12x10	Acetate Overlay
109.	Lungs	12x10	Acetate Overlay
110.	Fetus	11x8	Acetate Overlay
111.	Youngsters	10x5	Transparent Color
112.	Bacteria	10x8	Acetate Cell
113.	Bacteria	10x8	Acetate Cell
114.	Face	10x8	Acetate Cell
115.	Arm	10x8	Acetate Cell
116.	Human Parasites	10x8	Acetate Cell
117.	Park - Cartoon	10x8	Acetate Cell
118.	Volcanoe	10x8	Acetate Cell
119.	Doctor and Patient	10x8	Acetate Cell
120.	Bacteria Life Cycle	10x8	Acetate Cell
121.	Arm	10x8	Acetate Cell
122.	Armpit	10x8	Acetate Cell
123.	Skin Temp.	10x8	Acetate Cell
124.	Table	10x8	Acetate Cell
125.	Cartoon People	10x8	Acetate Cell
126.	Upper Body	10x8	Acetate Cell
127.	Arm Bacteria	10x8	Acetate Cell
128.	Body Outlines	10x8	Acetate Cell
129.	Skin	10x8	Acetate Cell
130.	Skin X-sec.	10x8	Acetate Cell
131.	Skin Cells	10x8	Acetate Cell
132.	Follicle	10x8	Acetate Cell
133.	Follicle Mite	10x8	Acetate Cell
134.	Girl & Buffalo	10x8	Pen and Ink
135.	Corn Grain	11x5½	Pen and Ink
136.	Africa Map & Ape	12x9	Pencil
137.	Moth	12x9	Opaque Black & White
138.	Boy and Beaker	10x12	Transparent Color

139.	Elephants	12x8	Opaque Color
140.	Dinosaur	9x9	Opaque Color
141.	Primitive People	13x9½	PMT
142.	Sea Animals	10x9	Opaque Color
143.	Moth Larva	9x9	Pen and Ink
144.	Gorilla	6x8	Pen and Ink
145.	Circulatory System	6x7	PMT
146.	Corn Shoots	4x5½	PMT
147.	Boy Falling	4½x5	Opaque Black & White
148.	Pregnant Lady	3x8½	Pencil
149.	Girl	3x8½	Pencil
150.	Man	3x8½	Pencil
151.	Pregnancy Study Guide	9x11½	PMT
152.	Seed Cross-Section	14x4	Pen and Ink
153.	Female Reproduction Organs	10x5	Opaque Black & White
154.	Seed Cross-Section	9x4	Pen and Ink
155.	Bean Seed	4x4	Pen and Ink
156.	Chimps in Tree	3½x10½	Pen and Ink
157.	Flies	6x6	Black and White Wash
158.	Flies	6x6	Black and White Wash
159.	Flies	6x6	Black and White Wash
160.	Youngsters	14x8	Pencil
161.	Space Knight	12x11	PMT
162.	Senior Citizens	14x7	PMT
163.	Health Chart	13x11	PMT
164.	People	12x10	PMT
165.	Girl with Horn	13½x10½	PMT
166.	Monument Valley	12x10	PMT
167.	Dog Catcher	15x9	PMT
168.	Adult Drugs	13x11	Pencil
169.	Sperm & Egg	16x11	PMT
170.	Cell Cross-Section	16x11	Pencil
171.	Tortoises	9x5	Pen and Ink
172.	Tortoise	9x6	Pen and Ink
173.	Fox and Rabbit	9x7	Opaque Color
174.	Rat Chart	7x6	Opaque Color
175.	New Mountains	4½x6	Opaque Color
176.	Mature Mountains	4½x6	Opaque Color
177.	Old Mountains	4½x6	Opaque Color
178.	Hares	7x4½	Opaque Color
179.	Spider	6x4½	Opaque Color
180.	Fiddler Crab	7x4½	Opaque Color
181.	Fish	6x4½	Opaque Color
182.	Octopus	9x7	Opaque Color
183.	Diatoms	4x4	Opaque Color
184.	Horseshoe Crab	6x4	Opaque Color
185.	Coral	7x4½	Opaque Color

186.	Abalone	5½x4	Opaque Color
187.	Sea Cucumber	8x5	Opaque Color
188.	Various Ads	13x14	Pen and Ink
189.	Galaxy	12x8	Airbrush Color
190.	Galaxy	12x8	Airbrush Color
191.	Africa Scene	10x8	Opaque Color
192.	Fall Deer	12x9½	Opaque Color
193.	Man on Trike	8x9	Opaque Color
194.	Child in Car	14x10	Opaque Color
195.	Baby Smoking	14x9	Opaque Color
196.	Ceral Boxes	20x10	Opaque Color
197.	Food Ads	20x10	Opaque Color
198.	Track Event	15x10	Opaque Color
199.	Boy Shaving	7x9	Opaque Color
200.	Girl Moutain Climbing	14x10	Opaque Color
201.	Boy with Tree	10x12	Color Wash
202.	Vegetation Chart	14x11	Opaque Color
203.	Farm - Aerial View	13x10	Opaque Color
204.	Beaver Pond	16½x12½	Opaque Color

COST FACTORS

The following includes costs of each technology from the original art to 1-inch videotape.

1. Artwork to 35 mm Motion Picture Film

Time to transfer 204 pieces = 3½ hrs @ $60/hr		$210.00
Film materials with processing = $45		45.00
Transfer film to 1" video = $130.25		130.25
	TOTAL:	$385.25
Cost per frame = $1.89		

2. Artwork to 16 mm Motion Picture Film

Time to transfer 204 pieces = 3 hrs @ $50/hr		$150.00
Film materials with processing = $22		22.00
Transfer film to 1" video = $130.25		130.25
	TOTAL:	$302.25
Cost per frame = $1.48		

3. 35 mm Transparencies to 35 mm Motion Picture Film

Cost of transparencies: Photography = 3 hrs @ $45/hr; Materials & processing @ 40¢ ea = $81.60		$126.60
Time to transfer to 35 mm motion picture = 1½ hrs @ $60/hr		90.00
Film materials with processing = $45		45.00
Transfer film to 1" video = 130.25		130.25
	TOTAL:	$391.85
Cost per frame = $1.92		

4. 35 mm Transparencies to 16 mm Motion Picture Film

Cost of transparencies = $126.60		$126.60
Time to transfer to 16 mm motion picture = 1/3 hr @ $50/hr		16.67
Film materials with processing = $22		22.00
Transfer film to 1" video = $130.25		130.25
	TOTAL:	$25.52
Cost per frame = $1.45		

5. **Artwork to 1-inch Video**

Cost to transfer art @ $1/frame		$204.00
Materials = $37		37.00
	TOTAL:	$241.00
Cost per frame = $1.18		

6. **35 mm Transparencies to 1-inch Video**

Cost of transparencies = $126.60		$126.60
Cost to transfer to 1" video @ $1/frame		204.00
Materials = $37		37.00
	TOTAL:	$367.60
Cost per frame = $1.80		

ALL COSTS ARE EXCLUSIVE OF ORGANIZATION AND TRANSPORTATION

TIME FACTORS

The following includes the time required to transfer the 204 pieces of art in the evaluation sample. Transportation time and administrative time are not included. These, in any case, would be similar for all technologies investigated.

1. **Artwork to 35 mm Motion Picture Film**

Preparation of art		3 hours
Time to photograph art		3-1/2 hours
Time to transfer to video		1/2 hour
	TOTAL TIME:	7 hours

2.06 minutes/art piece

2. **Artwork to 16 mm Motion Picture Film**

Preparation of art		3 hours
Time to photograph art		3 hours
Time to transfer to video		1/2 hour
	TOTAL TIME:	6 hrs 30 min

1.91 minutes/art piece

3. **35 mm Transparencies to 35 mm Motion Picture Film**

Preparation of art		3 hours
Time to photograph art		3 hours
Time to photograph transparencies		1-1/2 hours
Time to transfer to video		1/2 hour
	TOTAL TIME:	8 hours

2.35 minutes/art piece

4. **35 mm Transparencies to 16 mm Motion Picture Film**

Preparation of art		3 hours
Time to photograph art		3 hours
Time to photograph transparencies		1/3 hour
Time to transfer to video		1/2 hour
	TOTAL TIME:	6 hrs 40 min

1.96 minutes/art piece

5. **Artwork to 1-inch Video**

Preparation of art		3 hours
Time to transfer to video		2 hours
	TOTAL TIME:	5 hours

1.47 minutes/art piece

6. <u>35 mm Transparencies to 1-inch Video</u>

Preparation of art		3 hours
Time to photograph art		3 hours
Time to transfer to video		1 hour
	TOTAL TIME:	7 hours

2.06 minutes/art piece

FINAL REPORT

Media Design Associates, Inc.
P.O. Box 3189
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U.S. Department of Education
SBIR Contract #400-84-0009

COMPUTER MEDIATED LASER VIDEODISC ART RETRIEVAL SYSTEM

REPORT SUBMITTED,

Media Design Associates, Inc.

Bert A. Kempers

Bert A. Kempers, Principal Investigator

January 22, 1985

Date

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