Structures and Interactivity of Media: A Prototype for the Electronic Book

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Abstract

A prototype electronic book is proposed which is a synthesis of the access techniques of conventional books and interactive computing systems. It is the "Movie Manual" project, a powerful combination of technologies with styles of use modeled on those of a printed book, but with dramatically expanded powers of display and personalization. The Movie Manual is a training and teaching system that uses personal computing and optical videodisc storage to give its user access to text, sound, and images through a touch sensitive television screen. The result is a composite medium which embodies characteristics of traditional media such as books, film, and television, but provides access through a powerful and personalized interface.

Following a brief review of its predecessors, the Movie Manual system is discussed from its inception, through design and implementation, to its state today. Directions for further work are suggested, and the Movie Manual's future is considered, including generalization to other applications, and evolution due to advances in technology.

Key Words: electronic book/publishing, interactive videodisc, computer graphics

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Chapter One

Introduction

1.1 Overview

People have been writing and reading books for hundreds of years for learning, entertainment, even inspiration. Peoples' styles of book usage vary enormously, yet books for a wide range of subject matter have evolved with a set of common denominators that make them useful to millions of people all over the world.

Presumably it is these common denominators of books that are familiar and intuitively understood which make make books so readily accessible. There have been improvements in print quality and image reproduction in books, but the organizational structures of books, and many of the conventions devised to utilize them have not changed substantially from the way they were two or three hundred years ago.

The premise of this document is that an electronic book can be created which is a synthesis of the ways in which people use the conventional book, and an interactive computing system. This synthesis integrates images, sound, text, and graphics in an interactive surface that allows the reader to engage the system, actively explore its constructs, and personalize the book by literally writing it as a part of the act of reading. The work representing the synthesis is presented in the context of research from the same time period of its development. The explanation of its implementation is followed with a discussion of directions for future development.

The project described here is called the Movie Manual; it is the first investigation of its kind into a prototype electronic book, with the following significance:

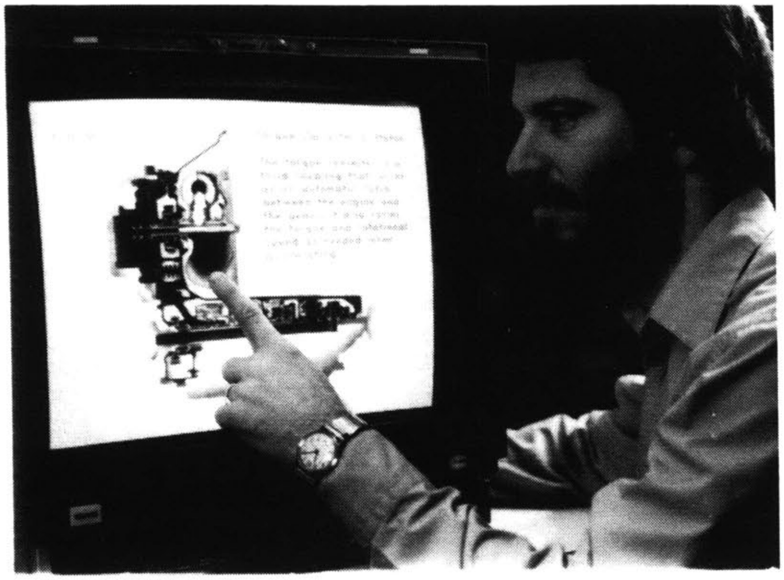

Figure 1-1: The Movie Manual

1. It maps the "access techniques" (that is, the usage conventions based on people's cognitive processes) of a familiar medium, in this case a book, into a computer system. The result is a general form, useful for education, research, reference, or as an organizational tool for personal information. Like a book, the techniques learned for operation of one of its kind transfer readily to the operation of another; but it is extensible, as will be described later.

2. In doing this, the Movie Manual extends the basic form of books to incorporate individualized publication: i.e. transforming a broadcast into a dialogue. By distributing a superset of information *and* the mechanism for perusing it, the book can appear to be individually directed. It can also be personalized by the conceptual addition of annotations and new information. The descriptive modes were also extended to include dynamically alterable and indexed text, sound, and motion.

3. The work of this dissertation also resulted in the construction of a prototype work/reading station where sound, data, and images are integrated into a unified whole. While many systems address the incorporation of these three presentation modes into single environments, in the Movie Manual they are coordinated: there is synchronization between the illustrations and movies and the text, and each may be used to control access to the other. Illustrations are thus not merely bit maps

inserted into a textual description, but are data available to the process that mediates the conversational access to the information. This prototype can be adapted to a wide variety of information dissemination situations.*

4. The Movie Manual also demonstrates an architecture for an exploratory/learning system, including an object-oriented database design and programming environment that are simply extensible. Unlike the standard programmed learning paradigm where there are programmers who create the system and programmed learners who wade through the creation, in this system the reader is the programmer. The creation tools by which the manual is assembled are accessible to the reader and form a simple yet powerful set.* .

   The Movie Manual system is presented in this dissertation in a general form, as a set of tools that may be tailored and extended to suit a broad variety of tasks such as learning, training, reference, personal data organization, entertainment, or communication.

The results of the work contribute to the areas of publishing, and building interactive computer systems. Both areas will continue to exist for some time, but have historically been distinct domains. This work explores their merger, by incorporating programming into reading for a conversational access system. The concept of publishing a database, in this case embedded in an optical medium, for which the act of reading is transformed into interaction with an active, cognizant processor is novel and represents new access techniques conceivably of lasting value equivalent to the concepts of page numbering, indexing, and tables of contents.

From a programming standpoint, the work addresses issues of the visual design of a computational book, the organization necessary to create it, and an interactive,

---

*The integration of multiple presentation modes has since evolved through several software/hardware technologies such as the AT&T Targa systems, and the MIT X Windows package.

*Although the object-oriented programming approach has existed since the early 1970's, it has been made more prominent by the announcement in August of 1987 of Apple Computer's "HyperCard" software, an object-oriented software environment and tool package to be distributed with every MacIntosh computer.

personalized manner for reading it.

1.2 The time perspective of this document

The work on the Movie Manual took place in a period of time (from about mid 1980 to early 1983) in which a number of strong influences had already broken ground in the field of interactive, multimedia computer systems. However, certain significant breakthroughs in hardware and in software design that would eventually be widely recognized as milestones in the field had not yet occurred. As a result, design decisions for the Manual that were quite novel at the time were made to anticipate improvements in hardware, and in interface software without knowing exactly what to expect. It was hoped that some conventions pioneered by the Movie Manual would set a new style of visual presentation and user interaction that would make it the antecedent of things to come. But it was unknown then whether the principles that shaped its design would be the same as those utilized by any major developments of the next few years.

This document, however, has been written during the period from mid-1983 to early 1988; as a result it has been done with the knowledge of break throughs in personal computers, storage technologies such as compact disc storage, several commercial adoptions of user interfaces that merge text and graphics for new styles of user interaction, substantial new interest in multimedia presentation, and numerous other developments. This creates problems in distinguishing between foresight at the time of the design process of the Movie Manual, and the hindsight of a contemporary view of the world.

To attempt to resolve this, the discussions of design attitude and motivation are written in the context of the time of the Movie Manual, to emphasize the forces and concerns that were strongest when the Manual was evolving. However, critiques of the design and its accomplishments are written with subsequent historical events in mind.

Some of these events are suggested as evidence to support the validity of the ideas that went into the Manual's design. But an effort has been made to balance the past with the present.

1.3 Assumptions about new media

As an investigation into a new media form, the Movie Manual project is placed in the context of a culture and a body of research about new media which embody certain assumptions. Although these assumptions are not shared universally, some that are frequently encountered (in research described in Chapter two for example) are:

1. When designing new media, it is beneficial to keep *some* familiar notions from traditional media to facilitate ease of learning and use. These include visual appearance (books, newspapers, maps, etc), organizational structures, and modes of usage.

2. A baseline goal of a new medium should be to preserve the same level of quality of presentation as the traditional medium on which it is based, in terms of appearance, and conveyance of information (for example, the Dynabook's goal of having text that was about as good as newsprint [Kay 77a]).

3. New media should extend and surpass the set of characteristics or features of traditional media by creating new forms of presentation, and novel means of user access and control. In doing so, developers should derive new rules for creation and production of materials for the new media.

4. New media should include active agents or processors that support the interaction between the user and the information embodied in the medium. This tenet comes from the domain of computing systems, and is a less generally accepted guideline. New kinds of media might well be developed without this as a requirement.

5. New media should be personalizable, so that at minimum the user can explicitly tailor aspects of the interaction as desired, or even better the medium adjusts itself to the idiosyncrasies and preferences of its user. This supports a sense of ownership that is still largely missing in electronic

media.

Some of these assumptions are based on the understanding that there are conventions and traditions embedded in our culture which can be used as points of departure for developing alternatives for the design of new media forms. Others are derived from the belief that new media must have the familiarity, convenience, and even the comfort of traditional media to be truly useful. But to be truly powerful and evolutionary, new media forms must go beyond passive, uniform presentations to all users by producing active and individualized communication.

1.4 The Movie Manual: design decisions

Given the existing body of work on new media at the time that the Movie Manual project began, certain approaches were chosen for the design of the Movie Manual in order to break new ground. The first design work in 1980 came before the announcements of personal computers such as the IBM PC or Apple MacIntosh, before Desktop Publishing via laser printer, and before data delivery via CD/ROM* . There were social forces that suggested a strong need for education of people with increasingly lower levels of education, and geopolitical currents underscoring the need for training in areas of mechanical skills. All of these contributed to the choices made for the Movie Manual.

1.4.1 The Book Metaphor

There were several reasons for adopting the book metaphor itself. The first was simply that projects at the MIT Architecture Machine Group laboratory frequently pursued a design philosophy which advocated borrowing from existing media those

*Compact Disc Read Only Memory, the 4.7 inch digital optical disc similar to the consumer digital Audio disc characteristics or metaphors which were both familiar to people, and useful as guides to the design of new interfaces. These borrowed characteristics were always only part of more comprehensive overall designs for systems with capabilities beyond existing media, but they helped make the systems accessible. This attitude contrasts sharply with the kind held in the design of, for example, an operating system driven by terse mnemonic commands that may be familiar only to computer programmers. To a large extent the person must adapt to the machine.

As an example of borrowed metaphors, characteristics of conventional paper maps were incorporated into the Movie Map ("Aspen project"), although it does not make cartography the primary means of presentation. Rather, it includes cartography to promote the "both-and" style of completeness, rather than a more limited "either-or". Notions derived from a personal style of spatial organization similar to someone's desktop were used in the Spatial Data Management System (SDMS) [Donelson 78, Bolt 79] (see section 2.2). Aspects of conventional printed newspapers were used in the NewsPeek electronic newspaper project.

This design philosophy is an attitude that emphasizes the value of utilizing cultural familiarities for design of interfaces to interactive systems. The first use of such systems may seem less foreign and more inviting, and subsequent use may require a shorter learning curve. Judging from the projects mentioned above, designs formed by that attitude have been reasonably successful in those contexts.

A second reason for the use of the book metaphor was that it provided open access to the contents of the Manual. Open access, as typified by a book, represented an attitude toward the reader of flexibility and willingness to support individualized exploration in reading. This implied that a reader's decisions about "navigation" through the information would be followed, rather than decisions forced on the reader by the system that would be restrictive, or sequential-access-only. The book is clearly under the user's control.*

In contrast, not all interactive videodisc systems have taken this approach. Some instructional systems, such as certain products for flight training or professional skills training, require the learner to go through the material in a fixed order, in which "backward browsing" of material already covered is sometimes permitted, but "forward browsing" (i.e. skimming ahead, or random acccss to all materials) is prohibited by the software system.

It is conceivable that rigid structuring of information may be necessary for certain specific types of training; however, the Movie Manual was designed to be a flexible, general purpose system. The open access approach makes it possible for the system to be tailored to the reader's interests. It also reduces the potential for frustration due to a lockstep pedagological framework. The question of whether to allow the user of a system the freedom to explore the content material at will, or to limit access has been debated for years, especially in the field of Computer Aided Instruction (CAI). The Movie Manual emulates the book in the sense that the materials are organized in a structure, but the reader can move within that structure freely; the Movie Manual goes beyond the book because the reader can rearrange the structure.

A third reason for modeling the Movie Manual on the book was that the book is a proven vehicle for communication. As a technology and a system, it is fair to say that the book has been "successful" for hundreds of years. Numerous highly useful techniques have been developed for the creation and uses of books which were seen as excellent guidelines for the conceptual design of the Movie Manual. Four main

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*This notion of user control is also reflected in the way the Movie Manual is written as well. The role of the reader is not restricted to simply reading; it includes the ability to add to or rearrange the book's contents as desired.

characteristics of books were used in the design of the Movie Manual: surface appearance, organization, modes of use, and opportunities for personalization. There were also some characteristics of books which were not used, and there were a number of ways in which the Movie Manual surpassed the conventional book.

1.4.1.1 Surface Appearance

A book-like appearance has several clear advantages: a display that looks like a page, with paragraphs of text set around illustrations carries quick recognition to anyone who can read a book. The size, shape, and arrangement of text indicate the significance of the material, and provide clues to the reader about how to interpret it. There are typographical conventions for conveying emphasis and explanation: boldface headings or italics convey intonation, footnotes and references point to additional depth, indented quotes indicate material attributed to others.

Compared to other modern-day communications media (such as movies or television) the book is perhaps the best medium which integrates text, graphics, and images in an accessible form, and therefore is a strong point of departure for the design of a multimedia communication vehicle.

There are certainly other paradigms for designing visual format. In fact, many computer systems have adopted the "multiple-window" visual interface developed at Xerox PARC for systems such as the Star, and later used by Apple (for the LISA and MacIntosh), and by others. However, in addition to being largely unfamiliar to people who are not computer users, the multiple window interface did not have the kind of access techniques as the book (for example, page turning), and did not appear as appealing. There may well be an equally workable solution to the design of the electronic book using a multiple window interface approach, which is the subject of another study. Research at MIT's Project Athena is investigating this and other topics, using real-time digitization of video for integration with graphics and text in interactive workstations [Mackay 88].

1.4.1.2 Organization

Books can have different kinds of organizational structures (linear novel, dictionaries, map books, etc.) but in the case of a book with a hierarchy, the table of contents is a useful aid that has worked for hundreds of years. The table of contents names the chapters, and each chapter in turn groups related information into manageable blocks of pages. Chapter headings, when used, are convenient indicators of the contents of the current locale.

All of these provide a logical semantic skeleton that is familiar throughout many kinds of books. While the semantic content is independent of a book's page boundaries, the page itself is a powerful syntactic boundary which gives the reader a sense of where he* is in relation to the whole of the book. As a different kind of organizational unit, the page is one of several media- inherent bases of orientation, or "media fiducials" described by Negroponte [Negroponte 78a]. Similar measures of progress for the reader are book marks and "dog ears", that are placed and moved as necessary. These perform important functions which are needed in new electronic media.

1.4.1.3 Modes of use

The electronic book can also be modeled on the traditional book's modes of use: scanning and browsing. The reader of a paper book does not always start at the first page and proceed uniformly to the last. He may glance at the table of contents, riffle through the pages to scan the layout, or he may skim the pages in search of something

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*Hereafter, use of third person singular pronouns is meant to refer to both genders. It is hoped that in exchange for less awkward syntax, the reader will refrain from reinforcing any sexual stereotypes.

specific.

When the reader finds the information he is seeking, he may switch to a more detailed mode of examination, involving slow reading and flipping back and forth. Similar options should exist for perusing the electronic book, and some book-like equivalents have already been investigated in other work [Bolt80].

To guide random access to information, the Movie Manual has an enhanced Table of Contents -- a visual equivalent of the book's -- that is a graphic representation of the subject. It names the chapters in the manual, but gives other information to the reader before a choice is even made: what the topic of the chapter is, and where it lies in relation to the whole, since the subject matter is a physical system (see section 3.2.3). Other physical examples can easily be imagined, such as anatomy, geography, etc, but the concept could work for a non-physical information space as well.

This visual table of contents is a alternative to the familiar text menu, from which the user can only choose an option. It provides more information to the reader, and it allows interaction via more than restrictive keyboard or function key input. In many systems, the menu selection mechanism is actually more for the convenience of the system than the user.

1.4.1.4 Personalization

Personalization is the tailoring of a system to suit an individual's preferences. The book has a number of such opportunities, the simplest being control over pace, which is obvious but missing in film or television. Books are also easily annotated. The reader can draw, underline, or add notes in the margin. These features are needed in the electronic book if it is to match the traditional one for usability. The Movie Manual supports these types of annotation, and extending these notions to include sound and pictures are significant topics for further work, as will be shown later.

1.4.1.5 Omitted Characteristics

There were some characteristics of books which were not included in the design of the Movie Manual. One notable example is page numbers. Since the reader was being given the ability to rearrange information and pages as desired, explicit page numbering was thought to be potentially too confusing. However, omitting page numbers created the need for other features that are normally served by page numbers. One of these is a way to remember a location if the reader leaves a page with the intention of returning, which is easily solved with a bookmark function. Another feature is the relative sense of location in the book that page numbers provide (although there are other ways of gaining the same sense in a paper book, such as the feel of the pages in front of and beyond the current page). This raises the issue of "navigational aides" that can give the reader a sense of location graphically.

Certainly, the Movie Manual is also not portable; this is one of the book's key advantages, and one that must be translated into future electronic books (see section 5.4).

1.4.2 Extending the book

From the beginning of the project, an objective of the design of the Movie Manual was to extend the capabilities of the traditional book by incorporating individualized publication: specifically, to transform a broadcast into a dialog. The traditional book is a broadcast in the sense that the same content is distributed to all recipients, and each recipient can do nothing to change it. Some computer-based instruction systems have been called "electronic page turners" because while the communication vehicle was the computer, the same content was being delivered to all viewers by means of rudimentary interaction, with really no options to alter or expand it.

The combination of the videodisc and computer generated graphics extends the capabilities of the Movie Manual beyond those of the static and silent book. But simply enhancing the modes of presentation, although exciting, does not fundamentally change the nature of the book.

The Movie Manual changes the broadcast relationship to an interactive exchange which approaches a dialog. It does so by providing a high degree of interactivity with all its components, which brings the power of interactive computing to the new medium. It exploits familiar symbols to provide new processes for the reader.

Most of the design decisions in this regard were made in the spirit of trying to invent or contribute to the "culture of interactive media" by reinforcing familiar conventions or creating new ones with what was hoped to be lasting utility.

This effort is based on the idea that there is a growth of new cultural expectations that result from the invention and use of consumer electronics, or commercial devices. Most people who live in typical urban settings are now accustomed to home Video Cassette Recorders (VCR's), digital watches, telephone answering machines, and so on. Each of these new devices has brought with it a set of techniques that people learn so that they can operate the machines. While different manufacturers often devise different ways to accomplish the same task, there eventually tend to be certain similarities common to almost all members of a particular class of device. As people encounter different makes or new models they often find that they already know how to operate the new one, because they have come to know what to expect for that genre.

A goal for the invention of interactive media should be to not only build the new system well but to design it so that it is placed in a context of familiar operations, so that once a person has learned to use one such system, encountering a new one will require little or no additional learning. This is perhaps one of the most powerful aspects of the conventional book: as a culture, many literate people have learned the essentials of reading and can "operate" a new book based entirely on the skills that they have used to operate previous ones. This approach to design is being explored in the industrial world by some designers who believe that long term utility will come from consistency and familiarity between different devices [Brown 87].

Providing interactivity with the Manual's components required invention. For instance, in the case of movies, there is a difficulty to overcome in that motion pictures seem intrinsically difficult to interact with; they almost "push you into your seat" and there is no clear mechanical interface to control them [Lippman 87]. The Movie Manual set out to exploit familiar symbols derived from consumer electronics as a means of providing meaningful control.

The movie controller resembles the "buttons" on a VCR, but allows the reader to utilize the features of the videodisc to control speed and direction, as well as jump to the beginning or the end of a movie. The controller was received with enthusiasm by visitors and users in the laboratory. A comparison study of alternatives might yield more concrete information about the optimum graphic design, function set, etc for such controllers, but that was not included in the scope of this work.

For interaction with text, which is normally static and "output only", the Movie Manual incorporates the ability for the user to explore interesting or unfamiliar words through touchable phrases that are similar to the "hypertext" concept (see section 2.3). An idea in context can be the link or entry to other information, which in turn can contain more explorable text with links to yet other text. This tangential expansion allows digression and reader-directed learning that is not available in the conventional book, except through manual exploration of a glossary, or laborious cross referencing via the index.

Similarly, graphic images are normally only a means of output. In the Movie Manual these can serve as a vehicle for input and exploration about a topic, as in the extended table of contents (see section 3.2.3).

As part of extending the book, the Manual's design models the present day publication process and reading process in a set of programs, in which the programming environment and database represent implementations of paper publishing components. Because of the extensibility of the database, and the ways in which new elements may be added, the system does not have to re-invent the manner in which a book is written, or how the data is organized each time a new book is started, or an existing one augmented. This is central to the notion of electronic publishing, and to the idea of writable environments as well.

Other investigations into electronic documents have taken different philosophical approaches to the creation and modification of materials. Some have made distinctions between the programmers, designers, and readers of the documents, and have localized tasks and capabilities accordingly (see section 1.6.2). The Movie Manual intentionally blurs those boundaries so that the reader can in fact rewrite the book as he wishes, in a writeable environment that goes well beyond annotations to the existing ordered pages.

1.4.3 Integration of Sound, Data, and Images

The prototype that was constructed not only integrated text, sound, video, and graphics, but it coordinated them in ways that support, reinforce, and offer access to the others. This effort at synchronizing the different modes of output allowed the members of the project to illuminate and experiment with different ideas, and make them tangible to others. The results were new means of user control via images and text, as well as a system that made it possible for a user to focus on learning via the preferred cognitive channel (for example, via sequenced text rather than verbal explanation, or vice versa). Some research has suggested that reinforcement through multiple channels increases retention as well [Gulliford 82] The philosophy in the design was again one that supported reader-directed learning, rather than learning through channels mandated by the system's creators.

1.4.4 System Architecture

Finally, the Movie Manual system was predicated on a modular, object-oriented architecture for both the database and the system software modules. This approach was chosen for several reasons: it tends to produce a compact and easily extendable system that can be expanded by several researchers working in different areas of interest. It can also evolve reasonably cleanly over time as new ideas and goals are proposed and pursued. In addition, the object oriented architecture has had success in the past, most visibly in the SmallTalk research by Kay and Goldberg (see section 2.3), one of the central sources of inspiration of this work. Other software systems such as "Objective C" [Cox 84] and C++ [Shopiro 87] continue to build on that architecture. The introduction by Apple Computer of "HyperCard" software has underscored the power and flexibility of this approach (see Appendix B), and may prove to be as significant a development as the MacIntosh computer itself.

There are of course other software architectures that could have been adopted, but on balance, the object oriented model supported a great deal of diverse styles and directions of investigation while still keeping the basic system robust.

1.5 Ideas versus implementation

Ideas about new techniques can generally be communicated to the public, or to members of a research field, in two ways -- by description (written publications, presentations at conferences, etc), and by implementation and demonstration. In some cases which are limited by resources or lack of technology, description is the only option such as with Vannevar Bush's essay on the hypothetical 'memex'. In other cases such as those restricted by political or corporate regulations, building and demonstrating research prototypes may be the only means of communicating new ideas to a set of observers, however small. But most projects are able to employ a strategy that combines both ways.

This question regarding philosophy of strategy is a major issue for any project that intends to break new ground. It is as much a question of 'how high do you set your sights' as it is 'how much to do you wish to realize'. The Movie Manual was designed to produce a demonstrable prototype that relied on standard hardware components, brought together by novel software. The innovations, and the hoped-for effects on the research community, were to come from the ways in which multiple media were integrated via a new interface metaphor, in an operational system. Extrapolations about what might be done further were not excluded from the design, but were not held more important than the realization of the first baseline of accomplishments.

The developers of the Movie Manual believed that its mixture of actual results and "pointers" to further expansion was the right balance of ideas and implementation. The Movie Manual created something at the cutting edge of its time, and opened a number of further directions of inquiry. This document is an effort to report those results, and draw attention to several open questions.

1.6 Context for the work: other contemporary research

The Movie Manual was developed from 1980 to mid-1983. Several contemporary research efforts illustrate alternative approaches to similar objectives.

1.6.1 "Macario"

The use of the videodisc for interactive instruction began in the mid- to late 1970's at MIT, the Nebraska Educational Television Network, Universities in Utah, and within certain government agencies. One educational videodisc program being explored around the time that the Movie Manual was being developed was the "Macario" interactive program created at Brigham Young University in 1979 and 1980. It presented a Spanish language film via a computer and videodisc based system, which gave the viewer opportunities to learn through computer text as well as the film itself. Developed at BYU under the direction of Edward W. Schneider [Sigel 80], it used the TICCIT computer assisted instruction (CAI) system to support the viewer's requests.

The program had a substantially different design approach from that of the Movie Manual in a number of respects. Its appearance to the user was not book-like (see figure 1-2). Instead, it used full-frame motion video with sound, or still frames with associated audio (from a computer-controlled audio cassette player) for most of the presentation. There were no graphics or text overlays on the video image, and the interface for user control was very basic. Computer text appeared on a separate monitor when the student interrupted the system by pushing a button. Choices were the made via the keyboard, as there was no X-Y input device such as a touch screen.

The Macario experience was different from simply watching a movie, because the viewer could interrupt and then choose an activity from a menu of options. However, the communication still took place via the film segments (or still frames) displayed under computer control. The basic unit of presentation was really a segment, created

Figure 4.3 Video disc/microcomputer hardware configuration for the Brigham Young University "Marcario" video disc. Courtesy Brigham Young University.

Figure 1-2: The "Macario" program

*

by dividing the film into its logical parts. This could be considered similar to the structure of a novel, but with somewhat more coarse subdivisions than pages.

The options that became available when the viewer interrupted the movie included reviewing a segment with either Spanish or English dialog, obtaining cultural or historical background information, accessing a glossary of vocabulary words, viewing a transcription of the Spanish dialog, and taking self tests. There were up to 23 different options, depending on the viewer's location in the film.

The implementation of "Macario" was certainly influenced by the technology available to the researchers at the time. There were no standards for the few microcomputers that could be bought, and videodisc players were experimental prototypes or first round production models still being "debugged".

The design of Macario relied on several key assumptions: first, that an existing

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*photo reproduced with permission, Knowledge Industry Publications, Inc, White Plains, NY 1980.

linear film could be retrofitted via editing to a videodisc application, enhanced with text from a microcomputer. Second, that images and sound did not need to be combined with text or graphic information. Third, only one function for interaction (the interrupt button) was necessary for the viewer watching the film. Once the film was interrupted, the other options were displayed. Fourth, there was no need for an X, Y input device for graphical interaction.

Different viewers of Macario would tend to have different experiences. However, all of the film would most likely be seen, as it was the "backbone" from which a viewer could digress; the cassette audio and associated text were used in a different manner than the materials in the "superset" approach of the Movie Manual.

1.6.2 Brown University computer-based documents

While interactive videodisc systems were being investigated, other researchers were specifically considering the concept of the electronic book, and with significantly different attitudes. Two are discussed here, to illustrate other directions that were pursued.

Researchers at Brown University developed a system for creating, modifying, and presenting computer based documents [Feiner 81], [Gurwitz 79]. The system provided tools for the creation of pictures using computer graphics, the layout of pages that associate actions with pictures or components of pictures, and the construction of chapters composed of pages.

Chapters would be grouped to form entire documents. The document pages or regions within a page are interactive by "picking" via an X, Y input device, which allows the user to select an area of the picture in order to activate some function connected with that area. There are a number of ways to view pages and move within the the structure of a document (see figure 1-3). Functions for navigation and orientation are available. The user can track his progress by viewing a time line of pages already seen, or browse an index linking other pages with keywords in the current page, or display a "neighbors" chart of logically connected pages. Users could however annotate pages by drawing with a stylus on an input tablet.

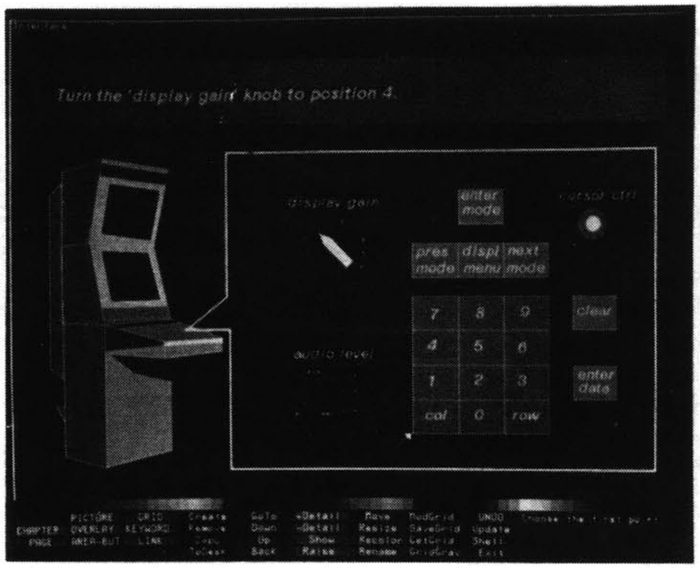

Figure 1-3: Page from computer-based document

This hierarchical design of component structures provides a modular framework for constructing documents, which are "directed graphs" whose nodes are pages. It also supports "Hypertext" style activities (see section 2.3) in which a user can follow links from words or concepts in one document to associated concepts in other documents. The pages were quite well-crafted and could be very detailed because of the high resolution (non-NTSC*) display.

There are two essential differences between the Brown University approach and the approach taken in the Movie Manual project. One is the accessibility of software tools, and separation of roles for those involved with the electronic documents. The

*National Television Systems Committee, the 525-scanline American television standard

Brown system defines three classes of individuals, and provides clearly defined sets of software tools for them: users, authors, and programmers. However, the sets of software tools for each group are different and somewhat exclusionary. The roles for the programmers, authors, and users are distinct. For example, authors for the system have access to software tools for page creation that users do not. Further, programmers for the system have access to other utilities that the authors (and users) cannot use.

A second difference in the design approach of the Brown system at that time was that the document pages were completely computer graphics based. Motion within pages came from color table animation, panning and zooming within the frame buffer, and some animation via rapid erasing and redrawing of selected objects in real time. The system did not include sound or motion video. The emphasis was on graphic and conceptual layout, rather than multimodal output.

Related efforts at Brown resulted in the development of Intermedia, a "Hypermedia" system (also a concept proposed by Nelson) that allows multiple people to browse, share, annotate, and edit a sophisticated corpus of linked graphics, text, and 3-D materials [Yankelovich 85]. Continuing projects are investigating better ways to visualize and navigate through large information spaces, to incorporate video and audio as an information resources, and to examine methods of searching through such complex webs of information.

1.6.3 A VLSI-based Book

Another design for an electronic book, which is telling in its focus on computing and storage rather than on the nature of its user interface, was developed at the University of Colorado College of Engineering and Applied Science. Based on large-scale Read-Only-Memory (ROM) storage, the design includes compression techniques for high density storage of text, complex string search capabilities, a distributed processing architecture, and flat-screen CRT display. It is described as having the potential to "alter the nature of libraries, increase the efficiency of the scientific, legal, and medical professions, minimize information access time in in industry, and modify the operation of the educational system" [Murray 82].

The proposed design would deliver powerful information retrieval capabilities in a compact, portable package. But the display proposed for this system (at last said likely for the first decade) is black and white only; most graphics are to be rendered with "character sets consisting of line segments having various orientations". It is mentioned that " ... optical disk memories may prove valuable in achieving high resolution graphics in this context", but none are included in the design. There are no provisions for motion pictures or sound, and the single means of user input is the keyboard.

This project, perhaps more than any other, underscores the difference between an approach which solves primarily the technical problems, without addressing the issues facing the user of the system. The design of the Movie Manual included efforts on various technical issues such as software architecture, database structures, and hardware configuration; but not at the expense of the user interface. The look and feel of the system, the experience as a whole, was held to be as important as the structures that defined its performance. The maximizing of the bandwidth for the user and the richness of the interaction were high priorities.

An electronic book need not necessarily be designed to have color, sound, motion, or a touch sensitive interface. But if the ROM-based electronic book is to be an omnibus medium for childrens' books and medical texts, the future with that kind of electronic substitute would appear grim. From the user's viewpoint, there would be a world of difference between the ROM-based book and the Movie Manual: how those issues are handled differentiates the work in the field.

Chapter Two

Predecessors

The Movie Manual has a number of predecessors which provided a foundation for further explorations of interactivity, visual presentation, and information access.

Yet the difficulty in finding a word or descriptive phrase to describe all of these forerunners is an indication that even classifying them is still a problem. There is no single, commonly recognized identifier that unifies all of them. Most of them are based on an interactive, multi-media concept that combines images, text, graphics, and perhaps sound, speech or other modalities in an engaging, two way process. The user of the system can guide the search for information, but the the system is an active presence that may guide the user to some extent as well.

These types of systems are sometimes referred to as "non-linear", in the sense that they are not intended to be used in a sequential or linear way as a novel is usually intended to be read from start to finish . The term "Hypermedia", coined by Ted Nelson to mean branching presentational systems [Nelson 74], has recently become more commonly used [Perry 87], but it is still not fully descriptive or accurate. For example, the traditional encyclopedia is not linear, but it is not "hypermedia" either. Hypermedia denotes a collection of information that is interconnected by links from one point to another so that a reader can move around within the information, but it further denotes different means of presentation and interaction. It is only recently that coherent studies of the interactive multimedia field have emerged [Ambron 88].

The predecessors presented here typically involve text, images, and perhaps sound, but the definition of the domain is not clear or even complete. Contemporary research is probing the incorporation of new types of animation, music, and speech recognition into multi-media systems, but what about force-feedback sensory systems, or synthesized smells ? The domain has been and is evolving as research is produced.

These examples, therefore, define part of the space of possibilities that is being considered, and in which the Movie Manual is placed. It is a very diverse space and it is clear that the Movie Manual overlaps many of these examples to varying degrees, but is also dissimilar in intent and orientation. This chapter is intended to show how the stage was set for the Movie Manual, and what schools of thought shaped its development.

2.1 Early Research

The possibility, and in fact the pressing need for a new way of storing and accessing knowledge was foreseen by Dr. Vannevar Bush in 1945. In his essay, "As We May Think", he wrote:

> "The difficulty seems to be, not so much that we publish unduly in view of the extent and variety of present day interests, but rather that publication has been extended far beyond our present ability to make real use of the record. The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze to the momentarily important item is the same as was used in the days of square-rigged ships." [Bush 45]

He explained that the problem was more than just one of improving the efficiency of modern library cataloging. It was the need for an organizational scheme that allows selection by *associative indexing.* He went on to describe a "private file and library", a memory device he called a "memex", which was a desk-sized machine that provided compact storage of tremendous amounts of information, a means of adding information via a "walnut-sized" camera that based on dry-chemical imaging technology, *and* a meaningful way to retrieve and interconnect related materials.

The key to its usefulness was the user's ability, through display screens, levers, and buttons to quickly locate desired information and link it to other relevant items, including his own entries. These links created associative "trails" for personally meaningful entries into the growing mass of the scientific and literary record. Even with Dr. Bush's conservative extrapolations of technological advances, the memex as described was a powerful model for an electronic library and publishing system.

Effective distribution of and access to information in the stored record were considered again in 1961 by Dr. J. C. R. Licklider* . In *Libraries of the Future* Dr. Licklider described the problems of access, which were seen to be due in part to the logistics of physically surveying millions of books on thousands of shelves. But in greater part the problems resulted from the "passiveness" of the printed page:

> ... the difficulty of separating the information in books from the pages, and the absence, in books, of active processors, are the roots of the most serious shortcomings of our present system for interacting with the body of recorded knowledge. We need to substitute for the book a device that will make it easy to transmit information without t ansporting material, and that will not only present information to people but also process it for them, following procedures they specify, apply, monitor, and, if necessary, revise and reapply. To provide these services, a meld of library and computer is evidently required. [Licklider 65].

A hypothesized example of an ideal "procognitive system", or an interactive terminal for access to the body of stored knowledge, is described which updates the predictions of future technology by using voice input, CRT displays, and buttons, but still strongly echoes Dr. Bush's memex in behavior.

Another early contributor to the culture of electronic documents and interactive access tools was the Douglas Engelbart, creator of the "Augmented Knowledge Workshop" at the Stanford Research Institute. Engelbart's objective was the "augmentation of the human intellect" by giving people tools for developing and

*In a study for the Council on Library Resources, established by the Ford Foundation communicating ideas. Starting in the mid-1960's, his research group developed a system that allowed individuals to write documents, make them available to others, and actually view and discuss the texts with others even when participants were in separate places.

The system, NLS (oN Line System), used CRT displays with windows (areas on the screen) for text and commands, a one-hand typing device "something like a kalimba" for typing ASCII letter codes [Nelson 74], the first mouse pointing device, as well as a conventional keyboard. Though it was accessible to only certain members of the research community at SRI and on the ARPAnet* , it provided a dramatically new way to communicate via text and speech and graphical input [Engelbart 73] [Engelbart 75] [CHItape 86].

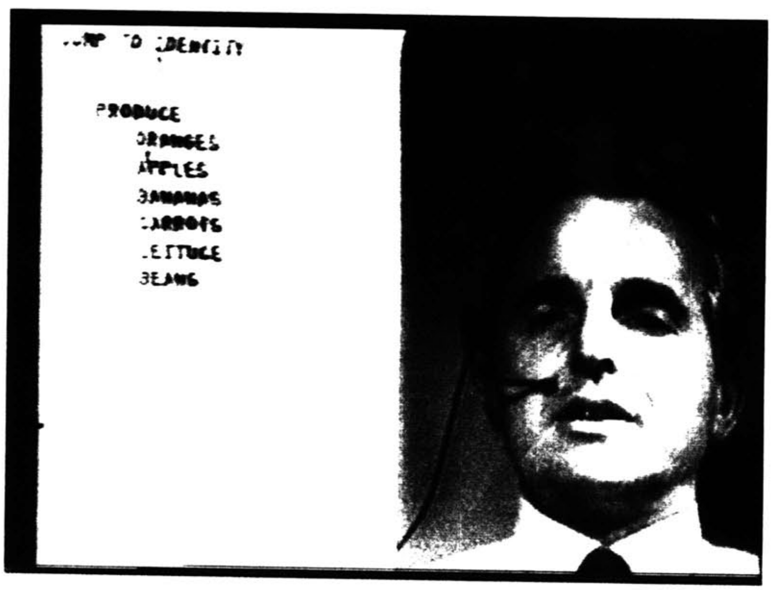

Figure 2-1: Engelbart's NLS

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*A network established by the Advanced Research Projects Agency in the Department of Defense

*From ACM "History of the Personal Workstation" tape, photo from film property of Douglas Engelbart

The NLS system created some of the fundamentals of the mouse and window user interface design that is now used widely in various commercial systems, including many of the workstation-class machines that support multiple window environments. But the user interacted via a command language rather than by selecting options from a menu, as is more common to some present-day systems. This supported a style of work that was and is familiar to computer-oriented people, but is not necessarily well suited to non-technical people. Nevertheless, NLS broke ground by developing new types of human-machine interactivity, and linking readers and writers of documents through a novel communication scheme that would influence other landmark developments for two decades.

2.2 Interactive Multimedia Projects at the MIT Architecture Machine Group

Two recent, but important research efforts that preceded the Movie Manual were the "Movie Map" (or "Aspen Project") [Lippman 80a, Mohl 81] and "Personalized Movies" [Backer 81, Backer 82, Correa 81], both of which utilized the optical videodisc as an image-store peripheral to the computer. Both also incorporated new approaches to a user's access to information through a visual interface that combined computer graphics and video images. Each could be extensible in concept to data access. But they differed in character and intent, however.

The Movie Map was a means of surrogate travel which allowed the user to "navigate through" an information space and build a mental model of that space. It explored touch sensitive symbols as controls for the system, and alternative uses of film as a means of representing an environment. The Movie Map kept many familiar notions from conventional maps, but extended the concept of the map to a dynamic, interactive experience. Most importantly, it developed a methodology in which complete and continuous interaction allows the user to adopt "the individual cognitive

Figure 2-2: The Movie Map

style that best suits him", in order to conduct his own research [Mohl 81].

The Personalized Movies project was an investigation of the addition of interactivity to movies, which also used touch sensitive controls to allow the viewer to control the pace, style, and level of presentation of the movie. This changed the structure of the movie from one of being edited before viewing and identical to all, to one which is edited as it is viewed, and tailored for each viewer based on personal preferences and interests.

The graphic controls were very simple, but they allowed the viewer control over the pace, style, and level of detail of the presentation. In addition, movies were redefined to be combinations of different kinds of visuals, including still frames, and superimposed graphic "notes" actually written by the viewer, as a means of personalization. The dynamic assembly of randomly accessed movie snippets overturned some of the basic principles of creating and editing movies [Negroponte 82]. As a result the presentations were a fundamental departure from traditional cinema,

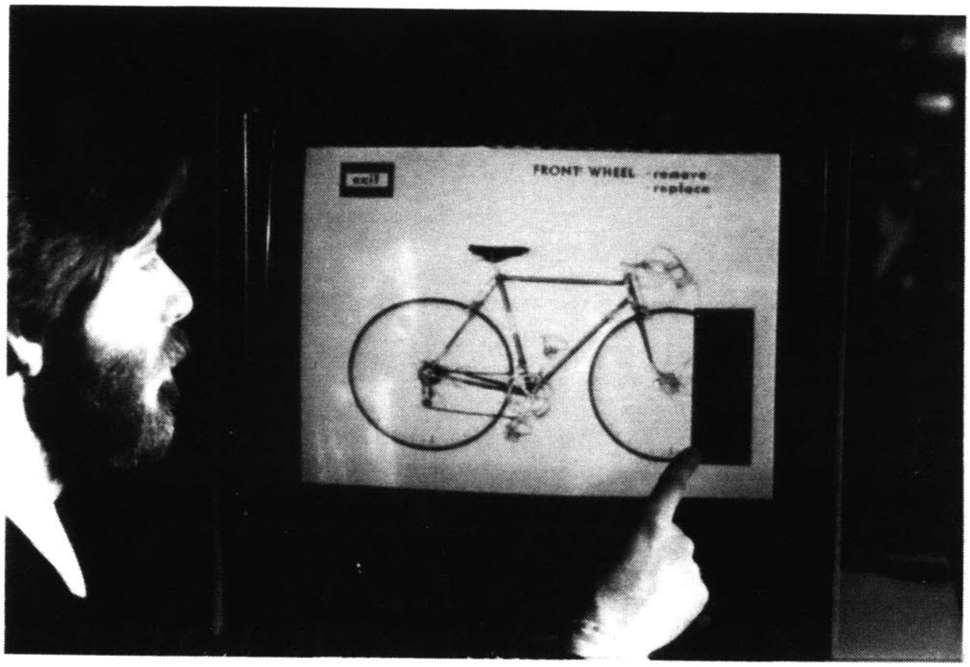

Figure 2-3: Personalized Movies

and from conventional interactive computing systems.

Another influence from the Architecture Machine Group was the Spatial Data Management System, or SDMS project [Bolt 79, Donelson 78]. SDMS offered a multi-channel interface which created an "informational surround" of large, high-quality displays, sounds, and touch sensitive surfaces. It drew on familiar and intuitive principles that people utilize that are based on spatial organization of information. One of the numerous visual data types in SDMS was in fact the book, which provided access to its contents through a touchable table of contents shown on a television monitor, and displayed pages that could be turned with the stroke of a finger.

These pages could also contain animated diagrams and sound accompaniments, and could be annotated with a simple stylus and tablet. Other kinds of active processes were available through computer generated graphic symbols as well. The readily identifiable images, combined with the easily used control techniques for the system, made the interface one that was quickly mastered. These techniques provided starting points for some book-like constructs that were developed for the Movie Manual.

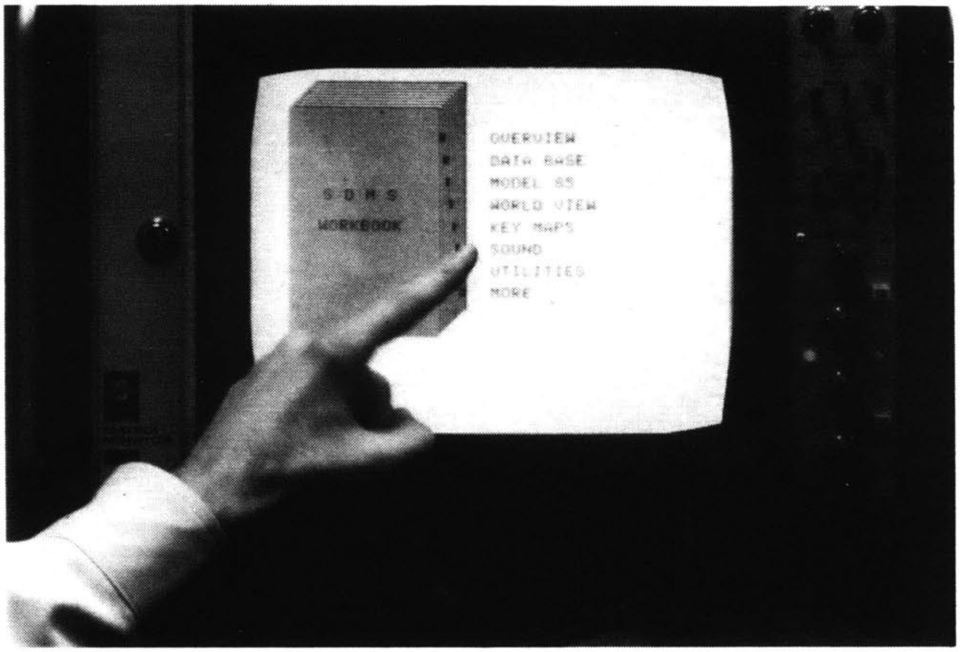

Figure 2-4: Spatial Data Management System (SDMS)

2.3 Other Systems for Interactive Multi-Media Presentation

A major precedent developed in the mid-1970's by the Learning Research Group at Xerox Palo Alto Research Center was the *Dynabook*, a design idea for a "personal dynamic medium" [Kay 77a]. The Dynabook was conceived as a "self-contained knowledge manipulator in a portable package the size and shape of an ordinary notebook". Its display was to be at least as good as existing media, that is, visual output at least slightly better than newsprint, and its audio output equivalent to high fidelity sound systems. The Dynabook included both black and white and color displays, a two-dimensional spatial input device (a mouse similar to Engelbart's), plus musical keyboard inputs and sound outputs (see figure 2-5). Its design was motivated in part by the sacrifices required by users of timesharing systems to gain access to computing resources, as Alan Kay described:

The best that timesharing has to offer is slow control of crude wire-frame green-tinted graphics and square-wave musical tones. The kids, on the other hand, are used to finger-paints, water colors, color television, real musical instruments, and records. If the 'medium is the message,' then the message of low-bandwidth timesharing is 'blah'. [Kay 77a]

The Dynabook proved to be a flexible environment for the implementation of software for creating, editing, and displaying documents, annotated children's stories, business graphics, paint system graphics, and musical composition. It provided one of the best models for subsequent efforts at developing an interactive multimedia systems.

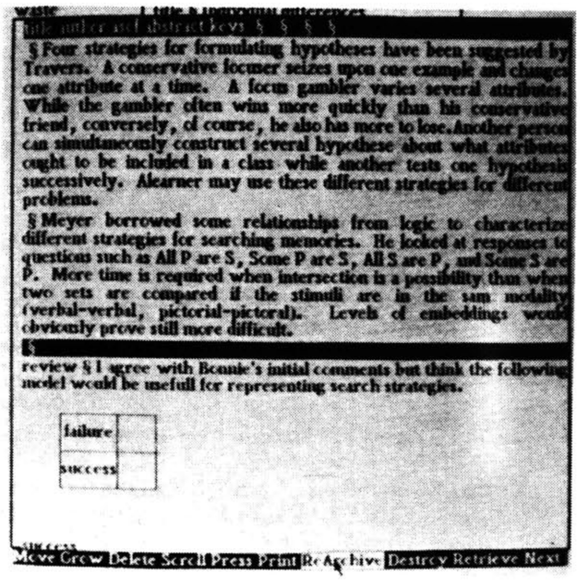

Figure 2-5: Page from the Dynabook

Ted Nelson, in his book *Literary Machines*, describes *Project Xanadu*, a system for the publication, archiving, and linking of documents through personal terminals. Its characteristics are simplicity in the user interface, and a "literary" model for interconnection of writings, in which original material referenced in a work may be easily found and even annotated by the reader, without changing the original copy.

Further, documents can be richly enhanced with links or "jumps" to related documents through the use of *Hypertext* (TM), a non-sequential writing technique connecting a point in a page to other points in other pages [Nelson 65] [Nelson 74] [Nelson 81].

Nelson's system is very much inspired by the memex, but it extends that idea through its proposed networking of terminals and storage centers. Documents may be created by authors, and "published" to be shared with the rest of the community under well-defined rules preserving the integrity of original writings, while managing traditional publishing activities such as copyrights, royalties, privacy, etc. Finally, the system is based on a design principle of simplicity, as Nelson states:

> "It has to be simple. It has to be powerful. It doesn't have to be complicated, in fact, it <u>can't</u> be complicated. And perhaps it can be built from the 'document' as we have long known it, the 'author' as we have long known him, and an extended form of 'writing' as we have long done it and read it..." [Nelson 81]

Some commercial software now supports the creation and use of Hypertext documents, such as the "Guide"* software package [RMiller 87], and Apple Computer's "Hypercard" (see Appendix B). The Hypertext conference of 1987 drew overflow attendance, and produced numerous reports on current research [HyperCon87 87]. Numerous articles have appeared about Hypertext or Hypermedia systems [Conklin 87], [Perry 87], [Marchionini 88], [Hanson 88].

But a Hypertext "library" will not exist until the text and other information for the documents has been entered in electronic form, and "linked" appropriately to the rest of the database. This is a substantial amount of work, whether done by hand or

---

From Owl International, 14218 NE 21st Street, Bellevue, Washington 98007 with tools that automate some of the data entry . This is a problem that will have to be overcome before any "memex" can reach out into the accumulated knowledge of the world.

The computer-based document system developed at Brown University, described in section 1.6.2, also shaped the design of the Movie Manual as a result of the evolution of the two systems during approximately the same time period, for the same sponsor. As mentioned previously, a number of the design decisions for the Movie Manual were intentionally different from those of the Brown system, but the two shared the common themes of electronic documents with interactive access to multiple modes of presentation.

2.4 Videotex and Teletext

Two other related precursors are the technologies of videotex and teletext. Both are forms of electronic publishing that use video output for a computing-based intermediary that receive digital data from a centralized source. Both systems could be characterized as not having enough computing power available at the user's end, as well as not having enough local storage for the image (i.e. poor spatial and color resolution). The lack of computing power adversely affects the system's ability for interactivity, and the limited local storage restricts the quality of the presentation.

In each, the "page" is also the smallest primitive element with which the user can interact. As a result, the user can only "cull" from a limited set of options. The success or failure of Videotex and teletext services have not been primarily because of their technological characteristics, but rather because of a mixture of business and

*For example, it may be useful to employ a printed text-to-speech converter such as the Kurzweil "reader" to scan large quantities of existing printed text into an ASCII database. This could then be cleaned up and interconnected to relevant documents

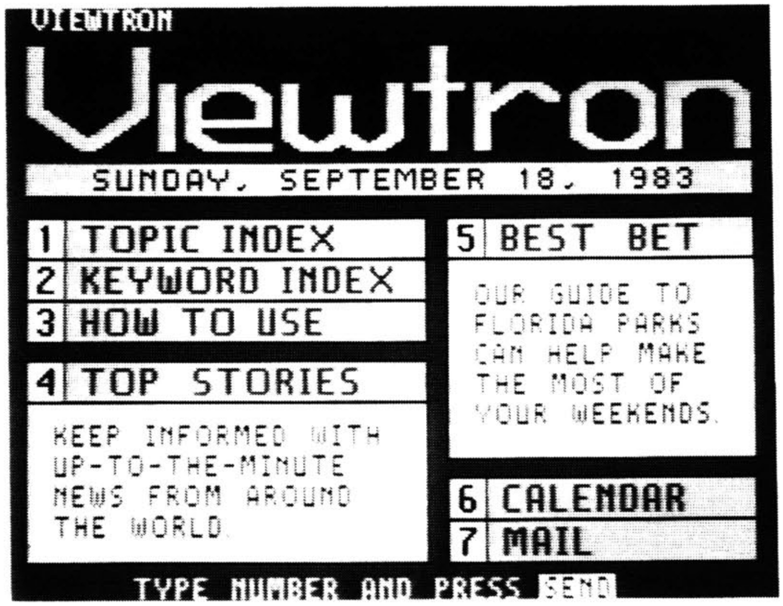

Figure 2-6: Videotex frame from Viewtron System

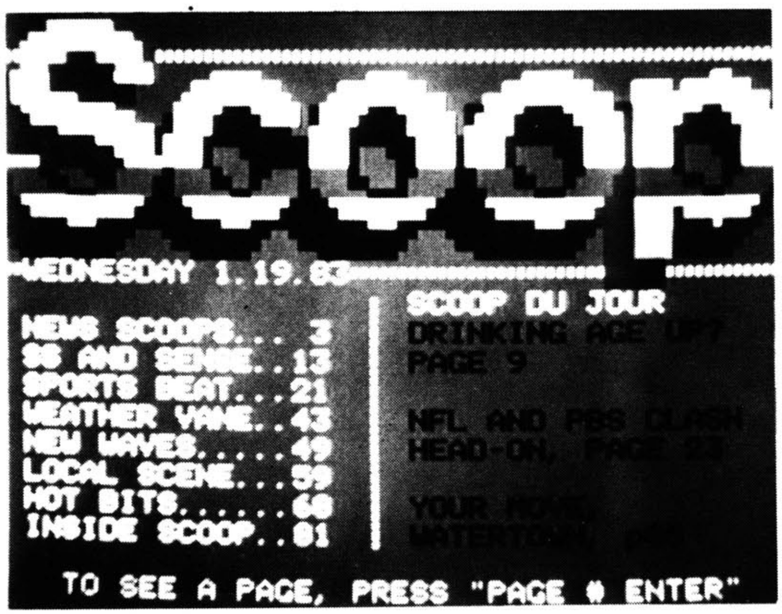

Figure 2-7: Teletext from WGBH experiment

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economic forces, combined with behavioral trends of consumers [Greenberger 85]. That underscores the need for the user's motivation for use of and engagement with a

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*image courtesy WGBH Television, Boston MA new technology.

2.5 Learning Systems -- CAI

Computer Aided Instruction (CAI) had its major growth in the 1960's and 1970's, and became widespread with the advent of time-sharing mainframes computers. Programmed lessons displayed text screens (and sometimes graphics) that allowed students to answer questions, play games, and otherwise interact with the programs that were available. Perhaps one of the earliest and most widely known of these systems was "Plato", developed by Control Data Corporation [Bitzer 71], [Nelson 74]. CAI systems have had another surge of growth due to the availability of microcomputers, which improved accessibility and facilitated program development on a more decentralized scale.

However, CAI has been considered by some to not have succeeded, because it did not deliver on its promise of educational revolution. Some systems did go far in putting computing power into the hands of non-programmers, and there are many derivatives of CAI operating today. CAI is still an active field, and different acronyms for subsequent efforts have also evolved, such as Computer Based Instruction (CBI), Computer Based Training (CBT), and Computer Mediated Education (CME).

2.6 Non-computational attempts at interactivity in other media

For three decades, numerous attempts have been made to develop engaging, reactive, quasi-two-way experiences in various media, such as film, television, print, and theater. Several of these are described in Appendix A. However, no matter how inventive these works have been, the common denominator among all of them is the lack of processing power or memory. The missing ingredient is the computer, and the software to support meaningful interaction. These are the keys to the synthesis of book and interactive system embodied in the Movie Manual.

Chapter Three

The Movie Manual

The Movie Manual system is comprised of an *interface*, a *model*, and a *programming environment* that binds it all together. The following sections explain each of these key elements, including details of design and implementation, and examples of operation.

3.1 The Interface

The interface is the mechanism for reading the book, centered around a touch sensitive screen. The presentation emulates some of the access techniques of the conventional book, and it occurs on a standard NTSC resolution television display on which graphics are integrated with video output from an optical videodisc player* .

It is worth noting that the touch screen, while commonplace today, was relatively rare in 1980 and 1981, but it had been the subject of much research at MIT including pressure sensitive versions of it [Weinzapfel 78], [Donelson 78], [Lippman 80a], [Backer 81]. It is not an absolutely necessary element, but is more than a convenient one. It allows direct access to the elements on the page or screen, and it is activated by the reader's finger, of which ten are always readily available [Negroponte 75]. A mouse or tablet could have been used instead. In the future, it is likely that speech and eyes will play a role in the interface, and the reader could envision having a conversation with the book, and that conversation might range throughout the room the reader is in at the time. What is critical is that the interface support this ***direct***

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*Two players were used, but one would suffice. This was simply an expedient to simplify prototyping, and is no longer necessary even with optical videodiscs -- see section 3.3.3.

interaction. It is necessary that the reader be able to "touch" the contents of the book, either with his hands, a pointing device, or alternately via voice, or eyes.

The NTSC television display, while of lower resolution than many of today's computer displays, made it possible to combine the computer generated graphics with videodisc output. There was already a rich body of research on high quality display of anti-aliased (grayscale) text and graphics [Catmull 78, Crow 78], especially on NTSC monitors [Negroponte 80a, Schmandt 80], so the television screen met the criterion that it contain sufficient visual and textual density necessary for "cognitive equity" with a printed page. Additional details of the hardware configuration are found in section 3.3.3.

The Movie Manual interface can be described in two ways: by a "tour" through some of the book's contents, and as a set of components.

3.1.1 "Sample Reading"

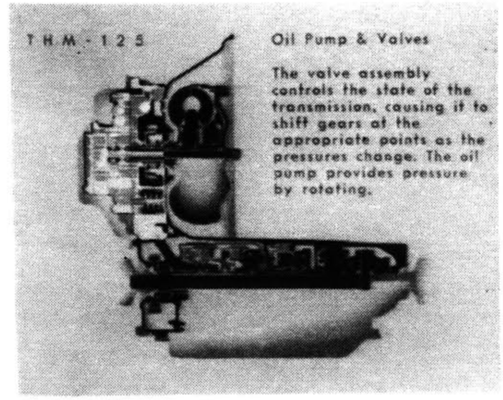
Reading the Movie Manual is a participatory, immediate experience that engages the reader through sight, hearing, and touch. It is filled with motion, sound, and color; conveying those sensations is difficult through a written description that is static, silent, and (to many readers) black and white. While a paper-based presentation cannot be a substitute for the real experience, it can still provide some understanding of the book's organization and appearance.

The following illustrations show some of the ways in which a reader can read the Manual* .

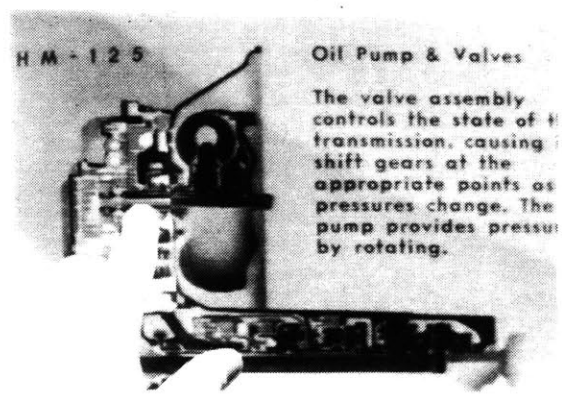
*A video demonstration can be viewed on the Architecture Machine Group videodisc *Discursions* - Side 1, Chapter 11, Frame 14000.

Figure 3-1: Sample Reading of the Movie Manual

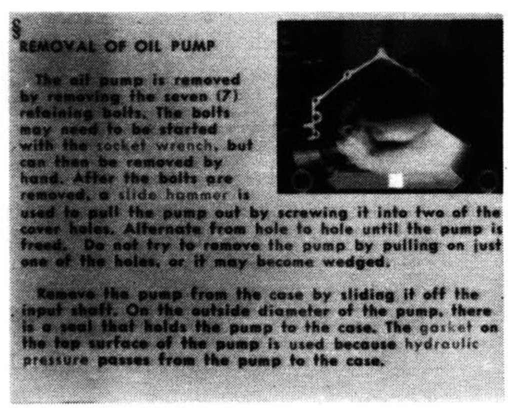
The reader begins at the touch sensitive table of contents, which shows the automatic transmission of a car in grayscale cross-section.



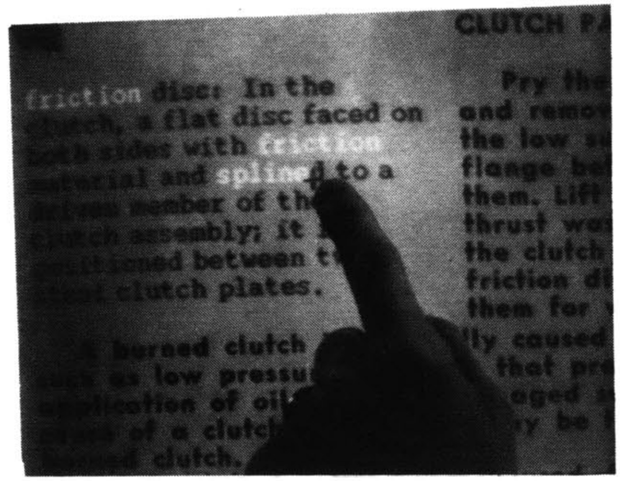
The reader "browses" through the contents of the manual by touching the picture. A touch in a particular region causes the appropriate sub-assembly of the transmission to be highlighted in color, and a short paragraph appears at the upper right that describes it. Each region represents a chapter in the book, which has pictures, sound and text.



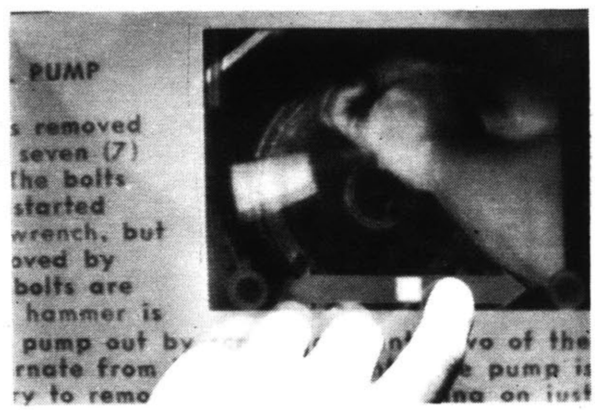
When the reader touches the text, the Manual opens to that chapter. The first page appears, with a description of a procedure and an illustration from the disc. The pointing-hand icons in the upper corners allow the reader to turn the pages forward or backward.



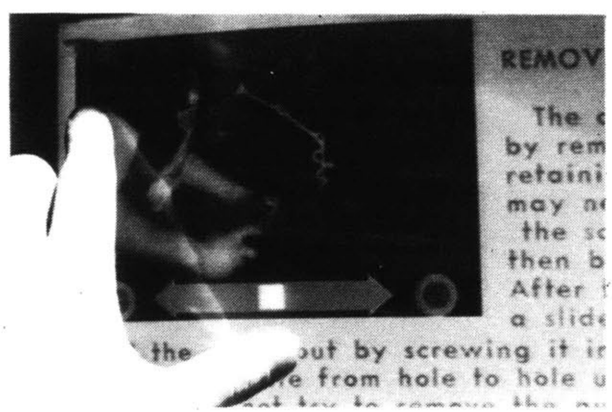
The words highlighted in color are glossary words, which the reader can "look up" with a touch. The definition appears on the page, and other glossary words within it may be investigated.



The illustration in the page is really a movie; the reader can play it in forward or reverse, at various speeds, by touching a two-headed arrow. The circle to the left is a rewind button, and the one to the right a fast-forward. The mechanic shown here is removing the oil pump.

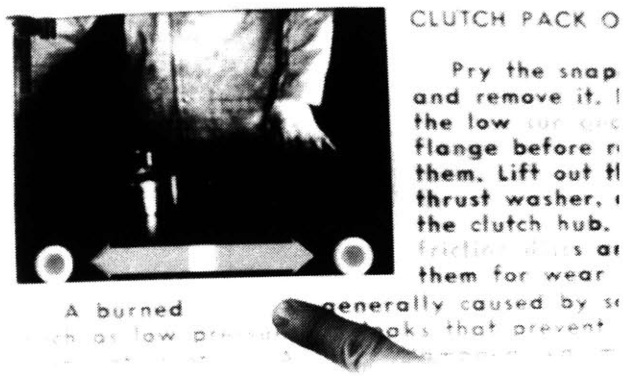


The quarter-frame movie can be expanded to full-frame by touching the bar in the upper left.

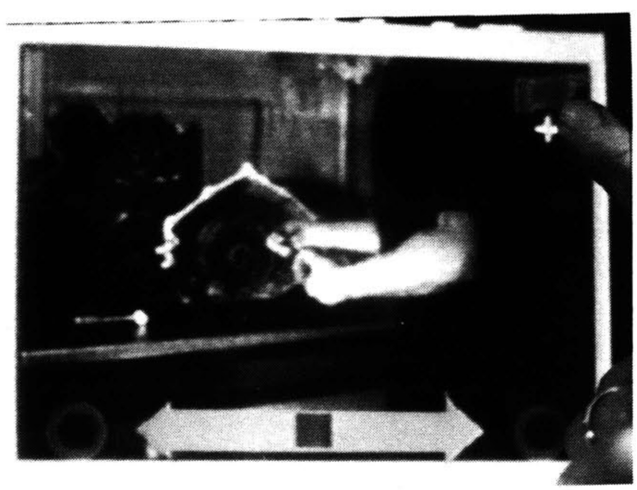


The same sequence appears as a full frame movie, with the same type of controls. Playing this version produces the synchronous sound recorded with the film. The reader touches the bar in the upper left to return to the page.

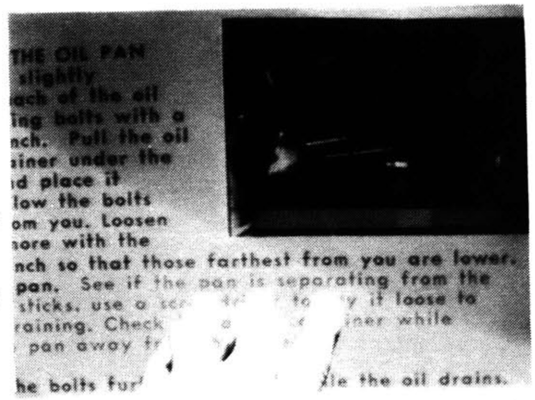
Some pages show motion using the pixillated, or "sparsely sampled" film footage taken at one frame per second. Overhauls taking 20 to 30 minutes are compressed into less than a minute of disc time, but can be viewed at any speed using basic movie controls.



Touching the next-page symbol displays a step-by-step procedure. Blocks of text are highlighted as the steps in the procedure are shown and narrated in the movie. In addition, a small highlight on the graphic slider in the movie frame indicates the relative position of the current sequence within the whole movie.



The reader may move ahead in the movie or replay a step by touching the text associated with that part of the movie. Touching the graphic slider will also select a sequence, which highlights the appropriate text block. No selection is made until the reader stops touching the screen.



Another kind of page shows what happens when a repair is performed the wrong way. This full frame step-by-step movie superimposes the text over the action one block at a time. Sometimes the most important thing to tell someone may be what NOT to do.

All of the live footage was recorded with synchronous sound, to provide the auditory cues of tool noises, parts moving, etc. that involve the reader in the process. Narration mixed with the ambient sound reinforces the text explanation.

When the reader leaves the last page in the chapter, the Manual returns to the table of contents, where the reader may chose another chapter.

3.1.2 Interface Components

As can be seen from the sample reading, the reader's interface to the contents of the Movie Manual is a set of pages composed of components (data base elements). The most challenging aspect of the Movie Manual was the design of these booklike interactive pages that serve as its "backbone". The solution was to dramatically broaden the definition of the "page" to include new kinds of interactive graphics, dynamically changing text, slides sequences, sound/narrations, and movies. But the creation of those new forms required some invention.

For example, the text-synch or step-by-step movie was created to coordinate movies, sound, text display, and graphics; it had no precedent other than in this work. However, the high degree of interactivity designed into the interface was matched with a commitment to quality and richness of display. This included color digital images and high quality text fonts. Tools had recently been developed for the digitization of images [Heckbert 82], and grayscale (anti-aliased) fonts had already been used for improved readability and variation in design in several projects previously [Schmandt 80, Bolt 80].

Several key ideas were developed to realize these new kinds of pages. First, high quality text and graphics were combined with partial frame videodisc images to achieve the page format itself, which made possible the user-controllable movies set in the page. This is perhaps the most distinctive visual technique developed by the Movie Manual.

Second, "Illuminated text" [Lippman 81a] was developed, which was a stream of text that contains embedded control codes, much like the text produced from a typesetter. The control codes mark words or blocks of text for special processing by the interaction handling software. For example, the glossary words that can be "looked up" in the dictionary are flagged with non-printing codes, so that the words can can be used as an index into the glossary. Text becomes a special category of data in which formatting codes and semantic interconnections between words and other elements in the Manual are interspersed with the ASCII characters.

The text is typeset as it is viewed, and it occupies a window fitted to the screen after the illustrations have been positioned. It can flow around pictures appropriately, in a manner similar to the text layout concepts that are becoming available in "display-Postscript* " systems. Because the Manual predated the Postscript conventions by several years, a subset of those types of primitives were specially created.

Text can serve as an element *next to* another element (such as graphics or video), or as an element *on top of* video by using transparent backgrounds. Thus the screen real estate can be variably allocated between text and images, depending on the importance of each in a page.

Third, programs were designed to synchronize text to images, sound, and graphics using data base elements. This provides the reader with the ability to drive retrieval of information through different means, and reinforce one channel of presentation with another.

Fourth, in keeping with the similarities to the conventional book, the Movie Manual's pages were organized in a truly randomly accessible manner. There was no provision for forcing the reader to follow a specific, predetermined path through the pages.

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*A page layout language by Adobe Systems, Palo Alto, CA.

3.2 The Model

The model for the Movie Manual is the conceptual organization of a book: a table of contents, chapters made of pages, and pages made of text, pictures, graphics, etc. The Movie Manual contains an extensible set that includes many of the elements found in a typical book, plus others such as movies and sound. This apparent organization is reflected in the various database types.

The Movie Manual database is built from a set of basic elements that can be combined in a wide variety of ways to produce many different forms of presentation. These elements are the "mapping" of the videodisc onto the database.

The Movie Manual's database is structured to allow the software to provide a high level of interactivity with each kind of element (pictures, sound, graphics, text) giving the reader variability and the ability to interrupt at virtually any time. Central to this ease of access is the smallness or "granularity" of the units that make up each data type, in order to support that interruptibility.

There are database classes for each type of key element. Instances of these classes are low-level objects that are combined to form higher level objects such as the pages of the manual. The low-level objects are typically arranged in a hierarchy, which can in fact be extended to the organization of the book's subject matter as well (although this need not be the case). These structures are illustrated below with an example page, and a possible arrangement of a book containing many pages.

3.2.1 Structure

The page is the backbone of the Movie Manual database structure. Pages may be interconnected in various ways (see section 3.2.3). The reader may interact with elements much smaller than the page, but the page is the organizational unit in the database.

A page is a collection of objects, some or all of which occupy the screen at the same time. The page may be a *superset* of objects of which a subset will be displayed for a particular reader (that is, only a part of the semantic unit may be shown at one time). Some elements may be invoked by a particular action, for example a page that includes a full-frame expansion movie. Other options in the superset might include a medium shot and a close-up shot of the same subject, from which the reader could select, or movies of a right-handed mechanic and a left-handed mechanic performing the same task so the system can respond to unique reader requests.

The page "knows" about its components and selects the objects and the order in which they will be displayed. Its knowledge includes the type of each component, and descriptor information currently used for formatting. For example, the basic movie is motion video from the disc, so its position is fixed; it is displayed in its location, then the text from a text window is streamed into a region that flows around the display region for the movie. Ultimately, this descriptor information may be used for more powerful dynamic page composition by the system, or for information retrieval functions that allow the reader to query the system to find appropriate elements, and thereby develop associative links to different parts of the database.

The example page described previously in section 3-11 illustrates how a high-level object can be composed of lower-level objects; it has four components (these elements represent basic display types which are described in detail in the following section):

These components are organized in the data structure shown in figure 3-3:

The text window is defined by a text-literal (another object) which is an ASCII string that can include embedded codes to indicate a glossary entry (see "illuminated text", section 3.1.2), and parameters describing the font type, size, and text colors.

* a text-window
* a basic-movie
* a "previous page" symbol
* a "next page" symbol

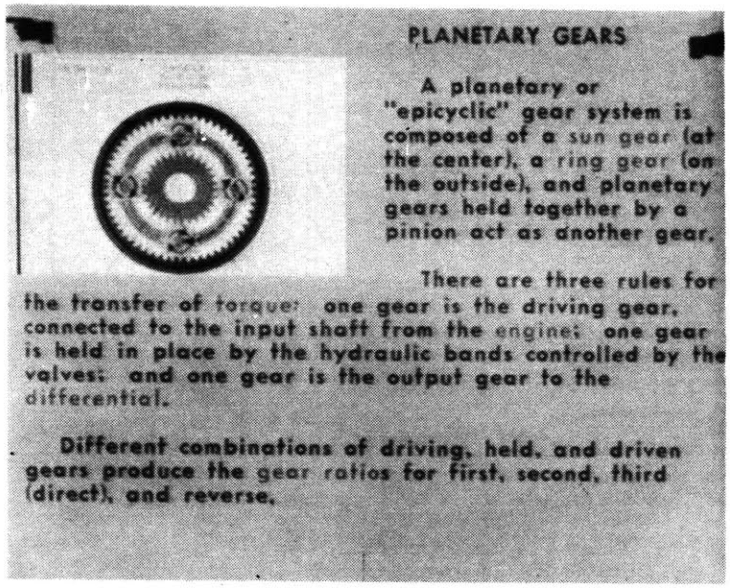

Figure 3-2:components of high level object

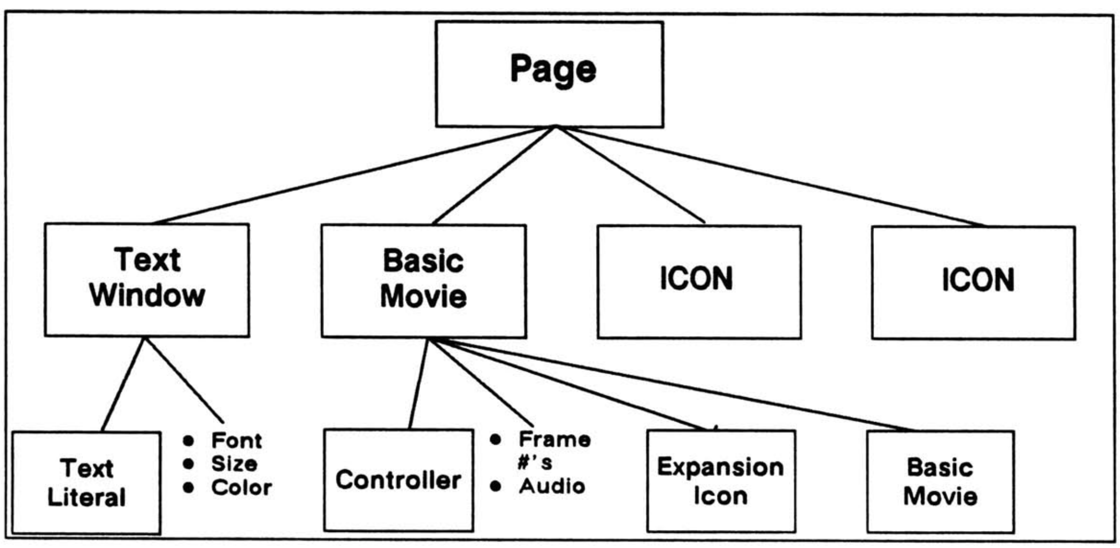

Figure 3-3:database structure for page object

The basic movie is composed of a movie controller (an object made of graphic primitives); the frame numbers and audio track of the video segment linked with the controller, and an expansion symbol linked with an expansion movie. The expansion movie is itself composed of another controller, frames numbers for a video segment, and a "return" control symbol.

The two symbols are small bit-mapped images read from files. These are needed as visible objects so that the reader will have a means of messaging the system to go to a preceding or following page. A separate control is needed for these options, because there is no way to embed them in the page in the same way as the glossary word lookup. Even using a speech recognizer requires a separate means of input from the interactive surface of the page itself.

3.2.2 Basic Elements: Text, Images, Sound

3.2.2.1 Text

The first of the Manual's key elements is <u>text</u>. It is supported by the "text_window" class, which stores passages of text, fundamental to almost any book. The text_window has as its values a text literal, which is a pointer to a block of ASCII text, plus a font type, size, and colors for both normal and "highlighted" display.

The text window addresses several problems common to many computer displays: access and quality. Text on most computer screens is displayed as single continuous stream which is scrolled off the top, line by line. Sometimes it cannot be stopped until an entire screenful has gone by. The text is generally unreadable when it is moving and in many systems, once a portion has disappeared, it cannot be easily recalled because the scroll is one-way.

In contrast, the text in the Movie Manual is dynamically cast into book-like pages that can be flipped forward or backward at the reader's discretion. The page is a syntactic chunk that gives a measure of progress through the pages in the chapter [Negroponte 78a]. The page is such a universally recognized display surface that it brings to bear familiar notions that can be exploited for interaction.

However, the design of the text forms in the Movie Manual is based on the hypothesis that the reader must be able to interact with elements of the text that are much smaller than an entire screenful. For example, the text window allows the reader to touch glossary words or phrases to retrieve definitions that are temporarily displayed on the page itself. Words within the definition may also be available for look-up, continuing the opportunity for exploration.

While the the ability to interact freely with the text in the Movie manual is essential, the quality of display is also important. Text on many computer displays looks bad. This is due to the use of a dot matrix scheme for character formation in which dots (pixels) are either on or off* . The dot matrix is usually chosen for the minimal size for which characters can be distinguished, but not designed. The resulting digitally generated signal suffices for non-interlaced 60-Hz monochrome monitors used for computer displays, but it degrades terribly on a standard interlaced 30-Hz color television, and is poor even on an RGB video monitor. It is difficult to display such a signal on an analog video screen and it results in coarse, jagged text which scintillates and produces unwanted color artifacts [Schmandt 83].

This low quality text was deemed unacceptable for the highly illustrated book that the Movie Manual is. A solution which diminishes these problems comes not from higher non-standard resolutions, but instead from the use of grayscale text fonts [Schmandt 80, Negroponte 80a]. Highly readable, near-type quality text can be produced on standard video monitors, generating what is perceived as a high resolution image on a lower resolution display [Lippman 78]. This is possible because

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*that is, "single bit" fonts with pixel values represented by one bit the edges of the characters are formed not by abrupt shifts in pixel colors, but instead smooth transitions created with intermediate tones. This "anti-aliasing" technique works for a variety of fonts (serif and sans-serif), in any color. The resulting quality can be used as a carrier of meaning, such as italics, footnote fonts, etc.

3.2.2.2 Images

Another component typically found on a book page is the image. Images occur in several forms in the Movie Manual.

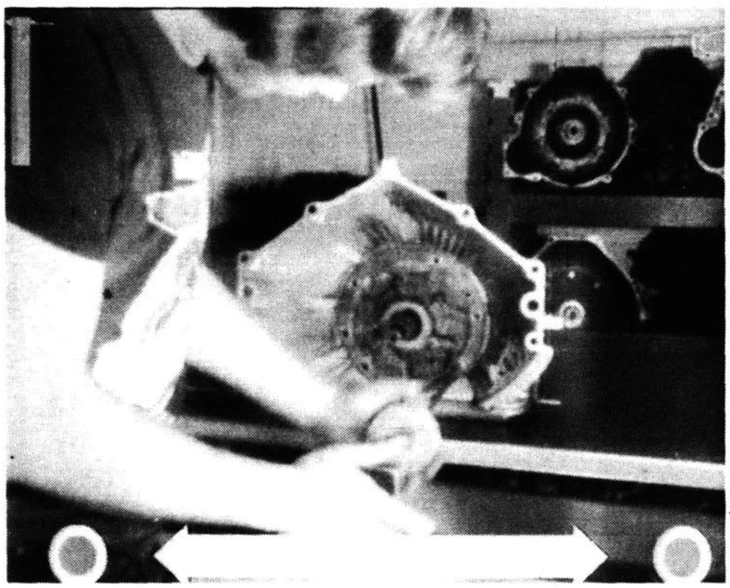

Figure 3-4: the basic movie

The first form of the image is the movie, either full screen or partial screen. Another form is one or more still frames, which can also be full or partial screen. Both are represented in the database by the "basic movie" class, which is simply a sequence of contiguous frames on the videodisc, with a certain fixed size and location on the screen. When a basic movie is being displayed, a movie controller object is placed in or near the window, or area that the basic movie occupies. This controller allows the reader to control the speed and direction of play of the movie, as well as restart it (see figure 3-4 for an example of a movie controller). The reader is able to exploit the full capabilities of the videodisc, rather than treat it simply as high-fidelity videotape.

Video images are also used in the "step-by-step" class, which coordinates video segments with sound, text, and graphics. The reader can see which segment in the series is currently being played, and can select any segment via the touch-sensitive graphic controller.

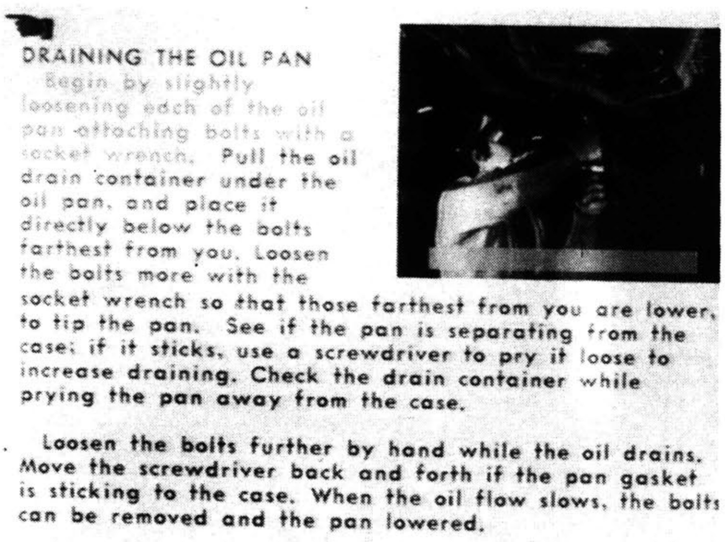

Figure 3-5: the step-by-step movie

Images also include any bit-mapped graphics displayed from the graphics frame buffer. These include software-generated shapes such as lines, rectangles, circles, etc (that may be combined with text on the screen), as well as "painted" and digitized (scanned-in) images.

These digital images may be stored as symbol objects. A symbol is usually small, and may be used as a touch sensitive controls for functions such as "next page", "previous page", or "return to table of contents". It is most likely a component of a higher level object, such as the movie controller in the basic movie (see figure 3-6). Symbols may be full screen images, such as the extended table of contents (see figure 3.2.3).

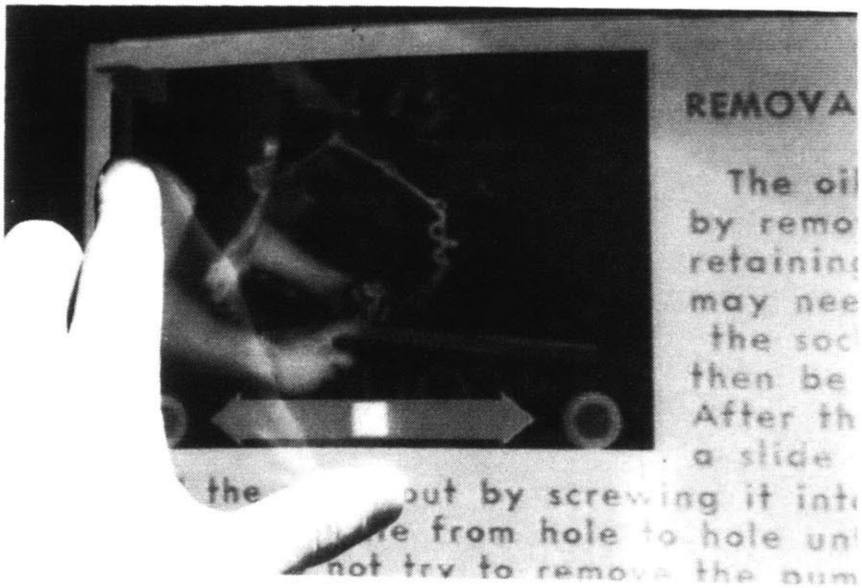

Figure 3-6: Touch sensitive icons

3.2.2.3 Sound

The third key element of the Movie Manual is sound. The use of audio underscores one of the strongest similarities (until recently) between computer systems and printed books: there is no sound. In contrast, the sound so omnipresent in broadcast television and modern movies that it is taken for granted is an integral part of the electronic book. The Manual's "talking pages" can convey the emphasis and personality of a speaker that silent pages lack.

Sound may be part of any object that uses motion video such as the basic movie, or the step-by-step; it is also available combined with still frames or graphic. It can come from either audio track on the disc, or both. The reader's control of the sound depends on the object type in which it is included.

Where sound is coordinated with blocks of text and movie sequences (as in the step-by-step movie), it is segmented roughly as phrases or sentences in a conversation. Part of a block would likely be finished as a whole by the speaker if interrupted, and can be repeated selectively by touch. The sound and movie segments that are coordinated do not necessarily have to have the same duration.

The sound that accompanies a "basic movie" can be halted at any time, making its smallest unit of time that of the video frame. This division of time (33 milliseconds) is an arbitrary one strictly due to the image technology, rather than a fundamental of speech. In fact, Linear Predictive Coding (LPC) schemes for sound assume speech to be fairly constant for 20 to 30 millisecond intervals* . Perhaps a more likely unit of size might be the duration of an average utterance, generally taken to be from 0.5 to 2 seconds in commercial speech recognizers [Schmandt 84].

If the Movie Manual adopted that unit of time, then an interruption of speech might therefore mean that the speaker is allowed to finish the current utterance before the sound is halted -- to continue to a good stopping point, as in conversation. The rules for this kind of content-dependent interactivity are not well defined, and bear further investigation. In any event, the true duration of an atomic unit of speech is most likely greater than that of a video frame. By giving the reader control over the sound at intervals the duration of a video frame, the Movie Manual errs on the small side to afford the user maximum control.

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*Due to the mechanical nature of the jaws, vocal chords, etc. which have inertia and are limited by muscular response times.

3.2.3 Higher Order Elements

Just as the page is a combination of lower-level elements, or objects, pages themselves can be organized into structures to form higher order elements. These higher order elements can in turn be organized to form a database for the Manual, called a book. There can be numerous books available for a reader, but only one is active at any one time.

There are numerous organizations possible which reflect different kinds of conventional book types; one structure that is typical in technical instruction manuals (the context for the Movie Manual) is as shown below in figure 3-7: it is a hierarchical structure similar to that found in its pages.

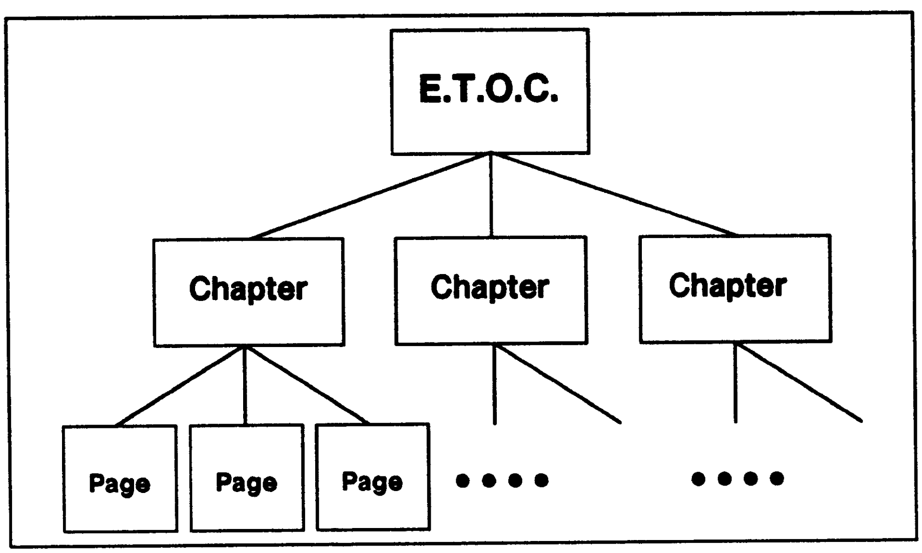

Figure 3-7: one possible organization of a book

At the top of the hierarchy is the extended table of contents (E.T.O.C.), an object which names the chapters of the book. Each chapter is also an object, composed of a description (a text window) used by the table of contents, some invoking rules that involve an input window region and a vocabulary for the speech recognizer, and a list of pages. Each page in the chapter, in turn, is a collection of objects, and the page "knows" how to display itself, based on some rules in its display method and a reader profile, maintained by the display manager. The display method orders its "display" messages to the components so that any video is shown first (for example a basic movie), then text and graphics. Each type of component has its own rules for display and interaction, in the methods for its particular class.

The extended table of contents is a high level overview of the chapters in the Movie Manual, and it is the first facade that the reader encounters. It is a valuable access tool, borrowed from the printed book, but transformed into a visual representation of the topic that is responsive to the reader's touch.

A table of contents can sometimes be an unnecessary layer, or impediment that intrudes between the reader and the data he wishes to find. This is especially noticeable with electronic systems in which all materials are not immediately randomly accessible. One example is the use of menus as a means of selection in a "stand alone" videodisc application: the list of options serves mostly as an expedient for the system to offer choices, and there is no payback to the user other than achieving the selection of one of the menu items. The problem is made worse for seasoned users by multilevel hierarchical menus that continue to ask a series of questions in order to isolate the destination, rather than produce the desired information.

The extended table of contents offers a different approach. A touch sensitive, graphic table of contents serves several purposes for the reader, and has been used (in simpler form) in the Personalized Movies project [Backer 81]. The table of contents for the Movie Manual is a graphic depiction of the subject (in this case, the automatic transmission) that serves as an interactive chapter map. When the reader touches an area of the picture, the system immediately highlights the appropriate region in the transmission which corresponds to that subassembly of parts, and which also represents a chapter in the book. At the same time, a short paragraph is displayed which describes that chapter, in high quality text (see figure 3-8). In this way the table of contents is a parallel presentation of information about a subassembly's physical location, name, function, and appearance in cross-section. As such it provides the reader a payback before any selection is even made.

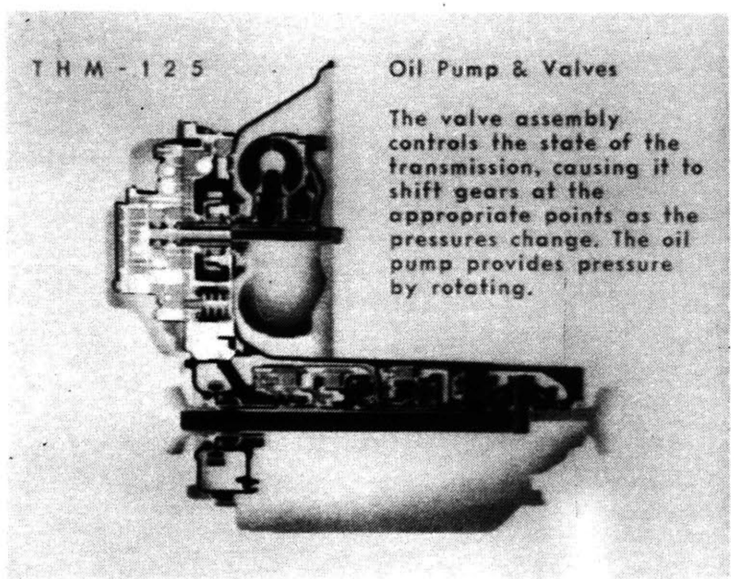

Figure 3-8: Extended Table of Contents

As the reader finger-browses across the display, different areas are highlighted in color. The explanatory paragraph is displayed only after the reader stops touching the screen. The paragraph for each region is its selector; touching the text "opens" the Manual to the chosen chapter. This browsing feature allows the reader to become familiar with the options by learning a little bit about each, without having to see everything. It also does not require the reader to state his goal in advance, which requires a well-formed idea of his purpose. So the reader doesn't have to know much to begin, either conceptually or mechanically (that is, how he is supposed to answer questions). Making a selection remains very simple, and there are no intermediate levels between the table of contents and the (destination) pages. A reader who already knows what he wants does not have to wade through many obstacles in order to get there.

The extended table of contents is currently implemented using a digital frame buffer image, which stores both gray-scale and color digitized pictures of the transmission simultaneously. Color matrix techniques are used to "peel through" to the color image in selected polygonal areas to obtain the highlighting effect. However, the same effect could be achieved by storing a number of frames of the table of contents on the videodisc, with each successive frame showing one of the regions highlighted. As the reader browsed, the right frame could be quickly displayed based on where the reader touched.

The extended table of contents is present more for the user than the system. But in addition, it is an immediate, engaging interface that encourages the reader to explore the Manual's contents in a very visual and tactile way.

3.3 The Programming Environment

The programming environment of the Movie Manual is the collection of resources that translate the conceptual book design into real form. These resources are the *software system* that generates the text and graphics, handles the interaction, and controls the discs; the *videodisc* itself that provides some of the materials represented in the database, and the *hardware* configuration that supports the input, processing, and output.

3.3.1 Software System

3.3.1.1 Object-oriented programming model

The Movie Manual is a general purpose software system that functions independently of videodisc content; there are no inherent "branches" or links in the software that force a reader to follow a particular path. Organization of the disc materials exists only in the database. This is a significant distinction from videodisc systems in which the controlling software must be rewritten for each new subject disc, based on the branching that the disc's contents are to support. This difference in approach represents an important step in the development and maintenance of the software: the system's functionality does not need to be rebuilt for each new application; only a new database needs to be created.

More importantly, the Movie Manual software architecture is an integrated set of procedures that assemble objects into pages dynamically. This concept could be called "dynamic geometry" because the geometry of the system at any given time should be a function of who the user is, and where the user is [Lippman 82a]. The pages that are assembled should reflect the information that the system has about the user, and what elements of the superset are available for that locale in the database. Thus the same informational element can be used as a building block by several different modules. There are frameworks, or "element types" that make this possible.

The Movie Manual software is modeled on an object-oriented system architecture, in which the elements of the book are independent objects which interact by sending and receiving messages [Gano 83a]. This type of architecture is an excellent vehicle for prototyping, and for development of a modular, extensible system.

Object-oriented programming is a design approach which separates the actions of a system's operation from the specifics of the implementation techniques and the data structure. Each element of the database, (i.e., each "object") is a member of a particular *class*. A class defines a set of database elements which have specific behaviors, and all the valid software procedures for that set of elements. Thus every element in the database is an instance of some class. There may be as many instances of a class as needed, subject to memory constraints for the database.

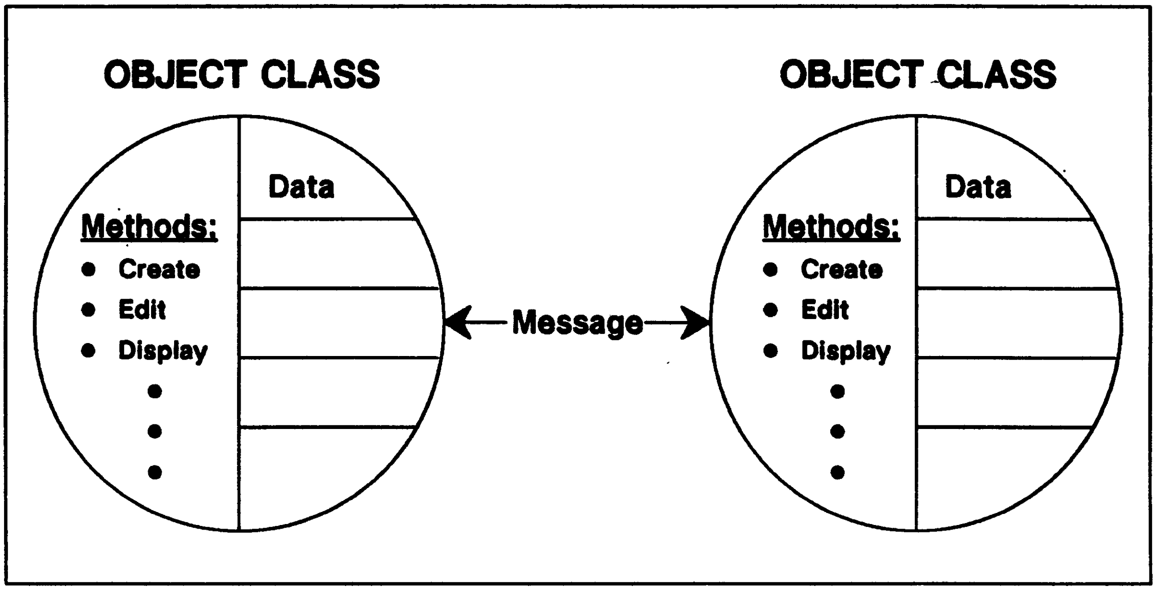

Figure 3-9: Object-oriented programming: Encapsulation and data abstraction

The procedures associated with the members of a set are called the class' *methods* or *behaviors*, and there are several methods that are "generic" to all classes such as "create", "edit", or "delete". Several others are common for almost every class, such as "display" or "tty_out". The concept of isolating all procedures for an object to this group of methods is known as "encapsulation", and the storing of all object-specific data structures within the methods is known as "data abstraction".

This message-object model is both a simple and powerful protocol for the system. It is simple because communication between objects can take place with a very standardized and compact set of operations. Objects can cause activity in other objects without requiring any knowledge of the other's implementation details (such as data structures or operators). It is also powerful in that the system can easily be extended to include new types of interactive objects without requiring any modification of existing classes or procedure software. To be added to the system, a new class need only meet certain basic requirements, such as having the necessary methods defined for itself ("create", "edit", etc).

When an action in an object-oriented system is initiated by some object sending another object a message to do something, the message is translated by the object itself into a conventional function call to the appropriate method. Therefore, the system "is responsible only for deciding what should be done; the object decides how to do it" [Cox 84].

Guidelines for the Movie Manual software design came primarily from literature on Smalltalk, the software developed for the Dynabook which is described by Alan Kay, Adelle Goldberg, and others [Kay 77a, Goldberg 76, Goldberg 79, Ingalls 78]. While the software system adopts some of the principles of object-oriented programming, it is implemented on top of a data-procedure oriented operating system environment, MagicSix. MagicSix is a Multics-like operating system, and PL/1 is the primary programming language for both systems and applications programs.*

3.3.1.2 Major Object Classes: the software system foundation

There are four major classes of objects. The first of these is called the "Object" class, so named because it is the administrator of all the display classes. Its instances are actually the display classes themselves, so it is the "Master" class of the system. Its methods are a collection of operations on display classes, concerned with adding and deleting classes to and from the system, enabling and disabling a class for debugging or modification, and managing the communication between objects.

The primary function of the "Object" or "Master" class is message dispatching.

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*Additional details of the architecture and implementation of the Movie Manual can be found in Steve Gano's Master's thesis [Gano 83a], and the Movie Manual Software System documentation [Gano 83b]

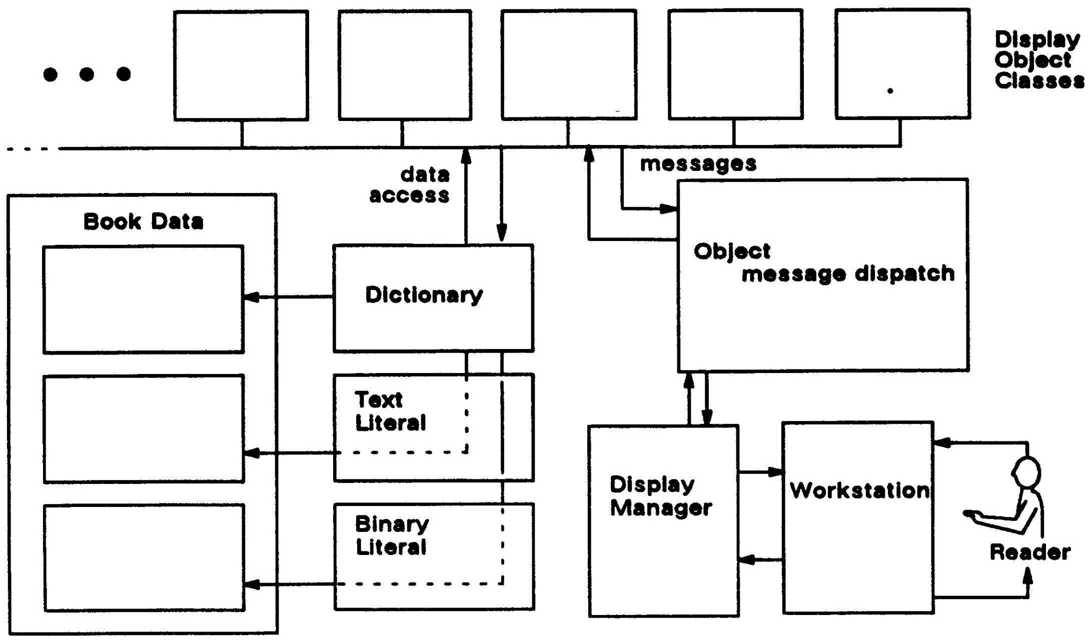

Figure 3-10: Movie Manual software system

The messaging is always of the form:

<action> <identifier> [<modifiers...>]

and the most frequently used message is "display" <objectname>, which instructs the named object to display itself. The messaging process is described in an example in the next section.

The "dictionary" class has only one instance for each book, and that is the data dictionary which stores the definitions of all the objects created for that book. Each definition, or object entry, contains the information necessary for its description and use, as well as the name of an object icon, or small digital image, which could represent the object in overviews, etc. This dictionary is also the book's index, which can be used for cross referencing, and generation of overviews.

The third major class is "literals", descriptions of the location and size of the data block which contains the actual values for an object, in packed format as part of a file* . Literals specify the file number, byte offset, and data block length so that the object values can be unpacked from the storage format. Literal class methods handle all of the storage management functions for the data files such as insertion, deletion, retrieval, updates, and output in readable form.

Finally, the "display manager" class is a class of hardware configurations. One instance of the class describes the devices of the current reading station. This means the display manager is the only component of the software system which knows the specifics of the hardware environment such as the dimensions of the frame buffer, details of the input devices, and instruction format for the videodiscs. Therefore, the display object classes can be defined for a virtual configuration, then transformed to the actual configuration at display time, since device dependence is localized to the display manager. Changes in the system hardware configuration may be incorporated simply by editing the display manager instance, or adding a new one.

The display manager also handles overlapping objects on the display surface, by building a "display map" which maintains a list of objects (ordered by display priority) and the areas they occupy. Thus, when the screen is touched, the display manager can determine which object "owns" the touch. Also, when an object on the screen is erased, the display manager determines those parts of previously obscured objects that should be uncovered, and sends messages so that they are redisplayed.

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*A MagicSix multisegment file, using available file management utilities in the development system. There are alternatives that depend on the implementation environments found in other systems.

3.3.1.3 System operation: example interaction

The operation of the system can be described through an example. A reader's investigation of a glossary term on a page illustrates the translation of the reader's gesture into messages within the system, and the resulting outputs.

The example page, shown in figure 3-11, consists of a combination of text, graphics, and video. The page is composed of several objects, namely 1) a text-window, 2) a basic-movie with a movie controller, and 3) some icons used for the "previous page" and "next page" options. When the page is displayed, each of its component objects receives a message to display itself, and it is during this process that the display manager builds its display map associating screen areas with object names (see display map).

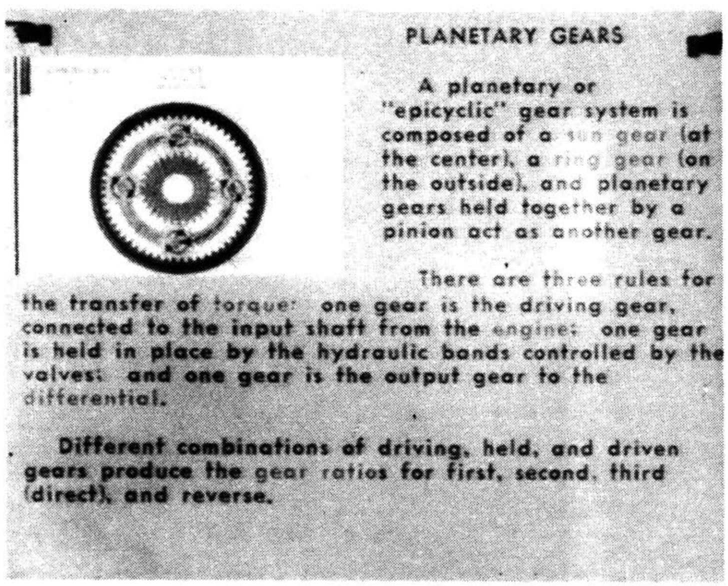

Figure 3-11: reading station screen

The reader initiates the sequence by touching a word on the display at the reading station (1) (see figure 3-13). The communications at this level of the system are physical actions (such as touching, typing, or perhaps speech input) and displays and sounds. The reading station is the hardware that comprises the interactive surface

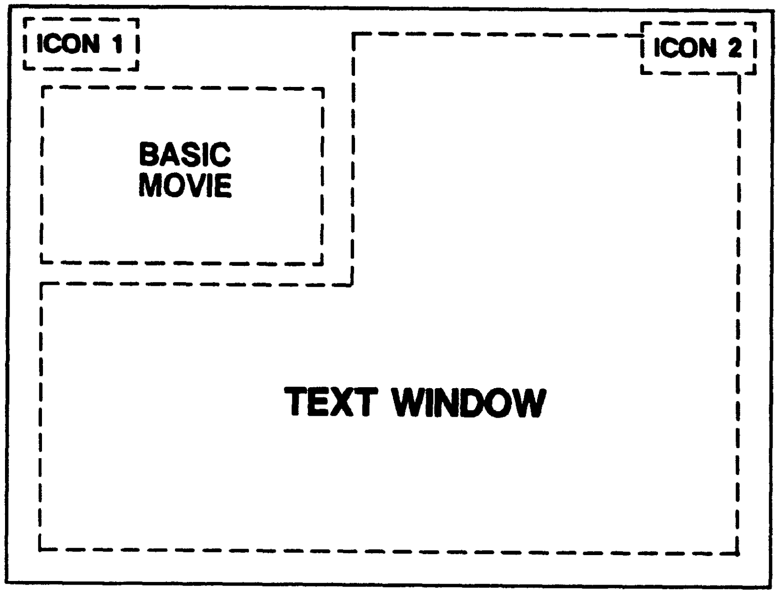

Figure 3-12:display manager display map

for the reader, described in detail in section 3.3.3).

The low level software controlling the reading station converts the reader's physical action into device-specific data transfers: X,Y coordinates from the touch screen, ASCII keystrokes from the keyboard, or vocabulary strings from the speech recognizer. The input data are then sent to the display manager (2) which maintains a model of the current state of inputs and outputs.

The display manager is the one component of the software system which knows the specifics of the hardware environment, such as the dimensions of the graphics frame buffer, operational details of the X,Y input devices, instruction format for the videodisc players, protocol for the speech recognizer, etc.

Device dependence is localized to the display manager, so the display object classes in the system can be defined for a virtual configuration, and then transformed to the actual configuration at display time. For example, window boundaries can be

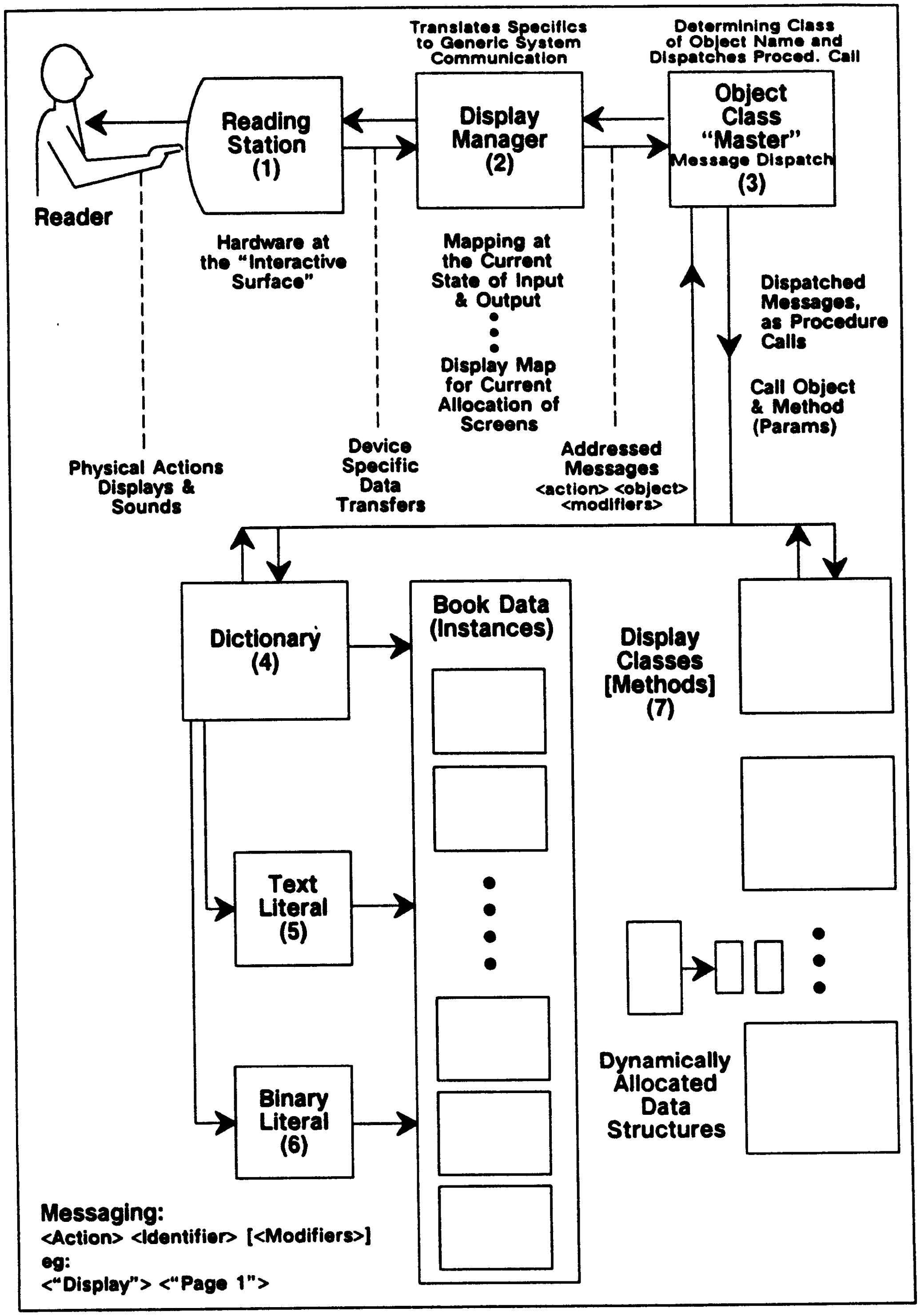

Figure 3-13: System Operation Diagram

defined in a world coordinate space* , then scaled and translated to the actual viewing space when displayed. Or an object may have a small vocabulary to which it will respond. If the reading station lacks a speech recognizer, the vocabulary is simply ignored or made available for keyboard input.

The display manager converts the device-specific input to some kind of addressed message, by mapping the input to the object that "owns" that input. In the case of an X,Y touch on the screen, the display manager checks its display map, which associates allocated regions on the display with an object name, and the method to invoke on that input. Once the owner has been found, the information is formatted into a message, such as:

"poke" "text_window_1" "x1, y1"

This addressed message is then sent to the message dispatcher in the "Master" class (3).

The message dispatcher is the heart of the system. It queries the dictionary (4) to determine the class type of the identifier in the message, and then translates the message string into a procedure call to the appropriate class method:

call text_window$touch (x1, y1, "text_window_1")

The display class method "touch" for the text window then interprets the coordinates, which in this case indicate a glossary word, so the method initiates actions that cause the glossary definition to be displayed.

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*the "Normalized Device Coordinate" technique could be used to define the screen as extending from 0.0 to 1.0 in both the X and Y dimensions. A scale factor would then be used at the device- dependent level to convert these "NDC" values to actual pixel addresses, which might range from 0 to 639 in the X direction and 0 to 479 in the Y direction for a frame buffer of size 640 by 480 pixels.

The "touch" method interprets these coordinates by using an important feature of the Window software package, which supports the display-mapping of text* . This is possible because data is generated when a text window object is originally displayed, which describes the locations of the lines and words in that displayed text window. The data is stored in structures which are maintained separately from the instance values in the dictionary, and from the screen associations in the display manager's display map.

The data in these structures is used to determine which line and word are indicated when the user touches a particular input point. That in turn can be used to determine whether the word is a glossary term (i.e., is bounded by embedded codes indicating a glossary string), or some other special entry. When a glossary term has in fact been touched, a message is formatted for the glossary to display the definition of the term. The place that the definition will appear will be determined by the display manager, based on the current layout of the page.

"display" "glossary_definition" <term>

The current placement algorithm first searches for a basic movie and if one is present, displays the definition in a text-window over the basic movie, which is typically a quarter frame. If no basic movie is present the definition is displayed in a text window with a size and location that will not obscure the original reference in context. If glossary words in the definition are touched, further definitions appear in the same text window as the first.

The message is then sent via the dispatcher to the glossary display method, which uses the term as an index into the glossary. The method finds the text for the term's definition (a text literal), and dynamically edits the text window of the glossary

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*Developed by Walter Bender in 1981, and used by several Architecture Machine Group projects.

object, so it will contain the new definition when it is displayed.

The message stream then follows the "return route": the "display" message to the glossary definition results in a message to the display manager, which updates its display map by allocating a new region for the glossary text window (containing the definition). The display manager issues commands to the appropriate text and graphics utilities, which output the correct pixels on the display screen. The reader can read the definition, and then touch another glossary word, repeating the entire process.

3.3.2 Videodisc: Materials Gathering and Database Creation

The information for the Movie Manual videodisc was gathered from a combination of original and existing sources. The objective during the planning and production of the disc was to include the widest variety of materials available, to provide a *superset* of the materials that any one reader would ever view. These components fall into three categories: video, sound, and data.

Many of the visual materials were included to test the suitability of existing slides, photographs, or line art (originally produced for the print medium) for conversion to the videodisc medium. This is important in terms of its implications for the production requirements of electronic publications in general. But original materials were also produced to try new production techniques, and to supply information not otherwise available.

As much as possible, the videodisc materials were gathered based on how they would be used with the system software, even though that software evolved considerably during the duration of the project. Producing innovative videodiscs is more a programming problem or content design problem than an imaging or recording problem. Not all the experiments succeeded as well as was expected.

3.3.2.1 Images

The majority of images came from original film. Sequences were "storyboarded" and filmed both on location and in a studio. Live action movies of transmission overhaul procedures were shot at the ITT Technical Institute in Chelsea, Mass. The film was shot in 16mm color, with synchronous sound using the "double system" technique* . Overhaul procedures were filmed at varying distances, from medium shots to extreme closeups, to provide alternatives for the viewer. Some procedures were filmed to show both a left-handed as well as a right-handed mechanic, to provide another alternative that might accommodate a different viewer preference.

In addition to the live (24 fps) sequences, a mechanic was filmed performing the complete disassembly and overhaul of a transmission at one film frame per second. This compressed time (or "pixillated") recording technique makes possible the storage of hours of filmed activity in a few minutes of disc "real estate", while still capturing the essence of the motion. Some of these film production techniques were derived from methods devised during the creation of the Aspen "Movie Map" (see section 2.2), which illustrate the need for inventing new rules for the production of new media [Bailey 80].

All the motion film was then transferred to video in two ways: first as full frame, and second as quarter frame, four to a videodisc frame, through optical reduction (see figure 3-14).

For still frame materials, the General Motors Corporation provided hundreds of original photographs and drawings used to produce their printed manuals, including schematic diagrams, exploded views, charts and tables, slides, etc. All these materials

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*In which images and sound are recorded separately at the same speed, synchronized by "slates", or signals that link the two recordings. The beginning points of a film take are marked on both the picture and sound reels so they can be aligned in the editing process.

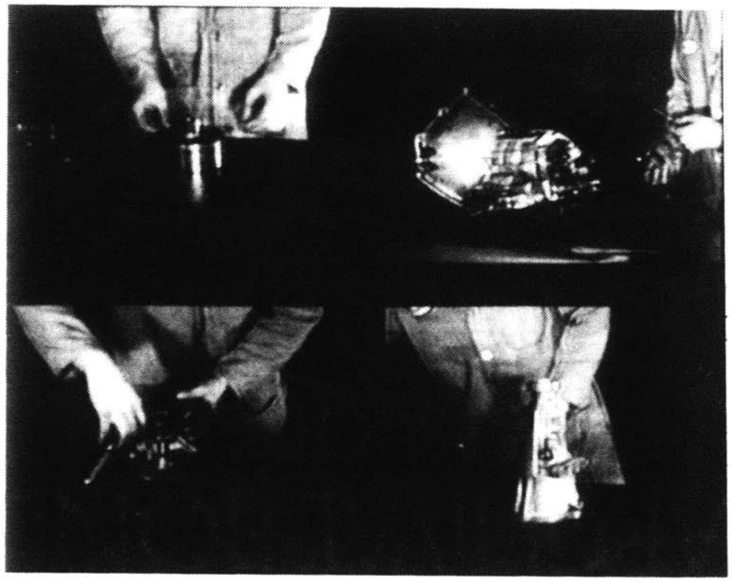

Figure 3-14: Quarter frame movies

were copied to 35mm slides, along with numerous photographs from library reference books about transmissions. These slides were transferred frame for frame to 35mm cinema film on an animation stand. As with the motion film, the still images were then recorded both as full frames and as quarter frames, and transferred to video.

3.3.2.2 Sound

The disc's two audio tracks are used for several types of sound. Synchronous sound was recorded with all live action footage. This supplies the ambient sound that the reader would hear while performing the repair procedures (in person). In addition to adding presence, which enhances the film's realism, the noises carry instructive cues about what the tools and parts sound like when the repair is being done correctly.

Two forms of voice-over narration were also recorded. On one audio channel, scripted narration is read aloud; on the other channel, the mechanic who performed the repairs explains how he did them, and what the pitfalls are. These verbal explanations are a means of presenting the same thing in different ways, and a reader can select one style over another; these alternatives can support different cognitive styles of learning when the reader is given the choice. There might also be times when the reader would want only to listen to the instructions, because he cannot read the text while his eyes are occupied looking at the machine.

The scripted narration provides a verbal counterpart to the written text, reinforcing the important points without exactly repeating them. The impromptued explanations by the mechanics who performed the repairs have a more casual, conversational tone. This kind of natural speech can say what just can't be written.

Although not yet a part of the Movie Manual, other kinds of sound could be valuable in the electronic book:

1. A great deal of potential exists for spatial sound, stored as stereo, to put the mechanic "into" the machine to add even more sensations to the learning process.

2. Translations of the narration into alternate languages can be published on the same disc and selected by the reader (along with the appropriate text), allowing the system to serve a wider range of readers.

3. Hours of digitized sound stored as data in video frames can be reproduced for sound-over-still narrations using commercial hardware.

4. By sending text (stored as encoded ASCII data) to a phonemic synthesizer, the manual can literally read itself to its user, pronouncing unfamiliar words, and explaining a written procedure when the user's eyes are not on the page. While this is currently done at significant loss in sound quality, it does provide another avenue for use of digitally stored text.

5. Ultimately, the user will be able to make his own digitally stored "sound notes" in pages of the book, by recording verbal comments or machine noises as reminders that can be replayed from the page at any time.

3.3.2.3 Data

The high bandwidth of the videodisc makes it a good vehicle for dense data storage. The Movie Manual can handle data directly from the disc, using appropriate decoding hardware to convert the video signal and correct any errors.

Even though nearly half of the disc's raw storage capacity is used for redundant encoding to support error correction, the following indicates the power of optical storage: one side of one disc would hold over 500 Megabytes. The videodisc's advantage, however, is that it can store pictures (moving and still), sound, and data together in one medium. Further details on the data encoding and decoding techniques can be found in [EBrown 83] and [Yelick 82].

The digital data stored on the Movie Manual disc comes in several forms. The General Motors Corporation supplied the bulk text for the Manual in the form of a magnetic tape containing the output from typesetting machines used in the printing of GM service manuals. Approximately a quarter of a million characters (bytes) of ASCII text, including typesetter codes were encoded for storage, at a density of 10,000 bytes per video frame. Higher densities are now available commercially* .

The text is retrieved from the disc, decoded, and displayed with high quality fonts (see section 3.2.2.1) in text windows which make up pages in the Manual. The text from the scripted narration read for voice-overs is also stored in digital form; both kinds of text might be "read aloud" to the reader via an inexpensive text-to-speech phonemic speech synthesizer.

Other kinds of digital data could be stored on the Movie Manual disc. One example is text for alternate language translation, to accompany spoken translations.

*Manufacturers such as Sony, EECO, United States Video, and others offer data encoding services which store digital data onto NTSC videotape, which can then then be edited into a master tape for videodisc pressing.

Another is the full database that describes the book's contents, which can be published in digital form as part of the disc itself. The software for accessing the database and running the system can be included as well, although software updates would be difficult to handle. For a mechanical device such as the transmission, the complete three-dimensional design data from a computer aided design and manufacturing (CAD/CAM) system could be provided for reference, or for computer generation of drawings and images.

3.3.2.4 Conclusions

In building the superset of elements for the Movie Manual, we learned that we could use some existing materials. This was certainly true for many of the still frames which came from photographs, slides, or line art that had been created for a print publication. Some line art illustrations and photographs are not easily distinguishable in video -- lists and tables printed in small type, "exploded view" diagrams with many dozens of parts and small text labels, and low quality black and white prints with minimal contrast. We experimented with techniques for "zooming in" on some pictures by replicating parts of the picture as full screen images in video. However, this is still not always effective, and this is an area where the images might be better generated in graphics, based on databases stored as digital data.

Large quantities of text prepared for printed manuals were also directly usable, either wholly or in part, for "text windows" in the Manual. However, some editing was sometimes required for style or formatting changes.

In contrast, we found that much live action film (video) is not readily usable for adaptation to videodisc, because it is paced incorrectly, or framed in ways that make it difficult to combine with computer generated graphics. The accompanying synch sound for existing materials may also be difficult or impossible to use in an interactive videodisc application without substantial re-editing.

We also concluded that some advantages can be created by storing certain elements on the disc more than once. For example, the quarter frame illustrations could be given the appearance of relocatability by placing them redundantly in each quadrant. The average search time to reach the digital data can be reduced by placing the digital data in several places on the disc. This also increased the certainty of having access to data uncorrupted by dropouts, etc. But these techniques are really technology specific, in the sense that they apply to the 12" analog videodisc, but would probably not be as relevant, or even necessary, to some other storage medium such as compact disc.

On the surface, the main effort in materials gathering seems to be in editing audio-visual materials to fit the constraints of a fundamentally different medium (interactive videodisc). However, the really important requirement for materials gathering is one of "attribute association", or data development for the materials. The key is that _data elements must ultimately carry with them the essentials of their own interpretation_, so that the internal system processes that make formatting or content decisions can determine where and how certain elements should be used. In some sense, this is similar to having a table of contents with every word, image, or sound. But it is the basis on which electronic publications can be extended far beyond their conventional counterparts.

This effort in producing data base descriptors is currently a manual effort, which is discussed in the next section. In the future, it will be an important challenge to develop "data integrators" for the production of fully "described" databases, in which the characteristics of the elements can be derived without excessive manual labor.

3.3.2.5 Database creation

A Movie Manual "book" is a database of elements (objects) that refer to segments of the videodisc for the appropriate video, stills, audio, or data. As mentioned previously, creating this database in the data dictionary is currently a manual process; that is, the first set of objects to make up a book are prepared by a designer (or "author") of the book. One major goal of the Movie Manual is to merge this creation or writing of the book with its reading, in order to blur the distinction between reader and writer, but some key aspects of the software required to make this happen are not yet at hand.

The objective is to build a "superset" of elements to provide a reader with more options than a uniform broadcast that is identical to all. This requires a rich set of objects that convey information about a particular topic in various ways. Ultimately the selection and formatting of these elements should be performed solely by the system itself, based on the attributes or descriptors mentioned in the last section and a profile of the reader that is developed over time. At present, however, the system selects the elements of a page from a set based on decisions made by designers as well as on its own.

As a result, a designer or author works at a terminal to develop the "superset" of elements that the Manual will draw on when formatting its pages. The designer draws on the designs and planning materials that were developed (storyboards, scripts, schematic diagrams of the chapters, etc) plus a frame log of the videodisc to create the database. The database creation tools are integrated into the Magic6 operating environment* so that Movie Manual objects could be created and manipulated in a way similar to other operating system objects.

Each object, therefore, is created and edited using the software methods

*The integration is via a new command line "listener" or processor associated with that object class. For example, a basic-movie object is created by typing

'create basic_movie <movie-name>'

where "movie-name" is an identifier that is the name of the new object. The fields required for a basic-movie are displayed by the create method (video start frame, video end frame, audio track(s), speed, output location), and the designer provides the relevant data. These values need not be filled in immediately, but they must be completed before the object can be displayed by the system. Each display class has its set of methods ("create", "edit", "display", "tty_out") so that the designer can build, view, and edit the objects for the book. Higher order objects can refer to lower-level objects that have not yet been created, but a higher order object cannot be displayed properly until all the components named within it are complete.

Objects can be displayed, viewed and re-edited very easily in a way that makes experimentation and fine tuning a highly interactive process. New elements can be added, others deleted, etc until the appropriate set is built. The resulting structure of elements is stored in the data dictionary, and accessed by the system at display time.

There are a number of utilities in the Movie Manual system that make the database creation simple. When assembling the components for a page for example, it may be useful to check the data dictionary for a list of all the basic-movies (that is, all of the instances of the basic-movie display class). This can be accomplished by typing:

dictionary$list basic-movie

The same search can be performed for any other class; or the entire dictionary can be listed if no class is given. There is a lot of power in the concept of a uniform working environment from both the database management perspective as well as that of the user interface. The effort was made to provide such an integrated environment, to the extent that was possible in a research prototype.

It is also useful to be able to see a high-level overview of the database, or at least a portion of it as a graph. A very basic "book visualizer" was developed to display the database by representing objects as boxes labeled with the object identifier, connected by lines to show the relationship of the elements currently defined [Schaefer 82]. A number of enhancements to the "outliner", as it was called, were considered, but not implemented. The "display only" outliner suggested that it would be useful to have a visualizer that allowed the book designer to not only see a database, but to interactively rearrange, edit, and display the components as well.

3.3.2.6 Advanced Software Tools

In developing these database creation tools, the need for some longer range planning and production utilities emerged. A great deal of the effort required for creating a database may in fact be already done very early in the design process, when the subject matter has been analyzed, and the elements for the book have been planned, but not gathered. The structure of elements may only be sketched out in pencil-and-paper fashion, but it is in fact the basis for the electronic data base which is to follow. Since this is frequently a process undertaken by several people in a working group, there are other problems that arise from a division of labor.

Therefore, database tools that would allow the sketching and modification of the design in electronic (that is, machine readable) form would provide the means of automating much of the currently manual effort. Similarly there are potential improvements in the coordination of activities among multiple database designers that could come from version control and document production.

These kinds of tools could produce the leverage for videodisc development that CAD/CAM systems produced for mechanical design and manufacturing. The key to their construction is simply an <u>integrated</u> <u>database</u> that represents the structure of elements that will be present in the data dictionary, and carries forward the key descriptors that define their content and value. Several powerful ancillary utilities could be derived from such a scheme.

The process of shooting and editing materials for a videodisc is a complicated one, no matter how much existing material can be used. The generation of production plans, and instructions for camera crews, etc during pre-production could be assisted greatly if the elements in a design could have additional descriptors attached during the production planning phase. Storyboards and scripts could be developed based on the "draft" for the database, and lists of details concerning location, equipment requirements, talent, or special timing considerations could all be stored and accessed quickly before or during actual shooting. Daily production notes could be stored in electronic logs keyed to the elements used to generate the shooting lists. A few commercial software products have addressed some of these individual tasks (for example, storyboard sketching programs, or production logging utilities), but none of them are part of a fully integrated system for the entire development process*.

The entire process as it takes place today is a complicated interconnection of many details; it is one that immediately lends itself to a database utility that could extract the right set of information based on a user's queries. It is also a logical part of the kind of foundation that is required to automate the generation of database descriptors that would be used in the display software. It would also be an important part of an expert system component in the Movie Manual (see section 4).

The post-production phase of the production process could also tie into such a

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*One package developed in 1987, the Computer Sciences Corporations' IV-D system, integrates some design information and production data for creation of an executable course, but without much provision for user interface, or variability in the course that results.

database. The editing of the raw materials on videotape into a finished master requires a great deal of selection, formatting and rearranging. One very useful tool developed by Steve Gano during the process of making the Movie Manual disc was Edit Decision List, or EDL. This program allowed arbitrary rearrangement of video segments via SMPTE* time code numbers (associated with the raw footage). Entries for the SMPTE time code were created manually, using 3/4″ videotape copies of the raw footage, which had time code displayed in the picture.

When the editing in EDL was done, a new edit decision list could be generated that showed not only the appropriate SMPTE time code numbers for each segment to be included, but also the equivalent frame numbers for the disc if mastered with the given edits. The output was on paper only, rather than in any machine readable format, but that was because the paper listing was sufficient for the work at the time. But with the right output device, a machine readable version of the EDL could probably be created to interface to one of several computer-based editing systems, such as the CMX-format* . If a database had already been derived from a shooting list (that is, extracted from the original plan), time codes could have been simply entered into the appropriate objects before editing. The streamlining of this step in post-production is an example of a potential improvement in productivity that could translate into time and money savings.

These types of software tools deserve further study. The entire process of design and production of interactive materials could be changed in much the same way that the process of developing written documents was changed with the introduction of word processors. The redundant, manual steps can be automated or removed, so that

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*Society of Motion Picture and Television Engineers

*CMX is the computer assisted videotape editing system developed by the CMX Company in in 1970 (now from Orrox Corp. Santa Clara, CA.)

people can spend their time on the content and design issues rather than the mechanics of the process. This could reduce development time and improve the overall quality and impact of the resulting videodisc, and could eventually produce databases that support a much more powerful software system.

3.3.3 Hardware Architecture

3.3.3.1 Configuration

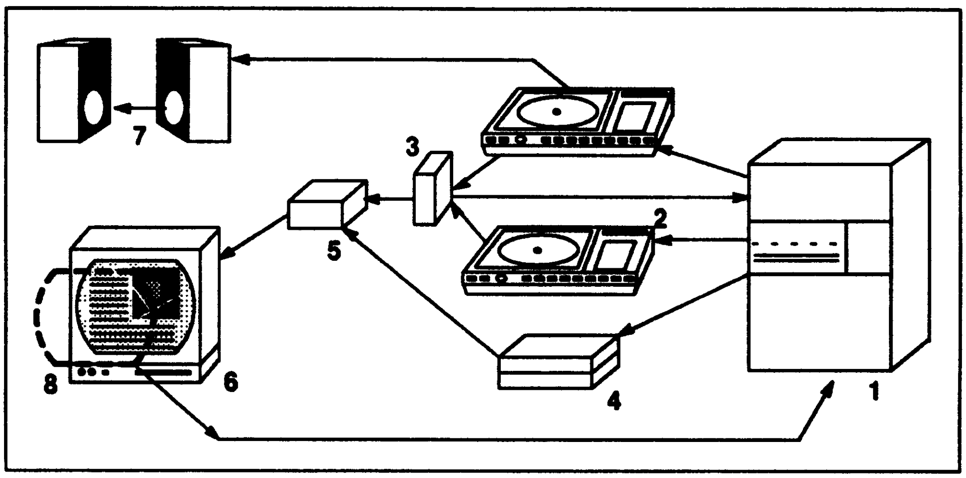

Figure 3-15: Movie Manual Hardware configuration

The Movie Manual operates in a hardware system developed at the MIT Architecture Machine Group that is an extension of common configurations for interactive videodisc systems (see figure 3-15). The computer (1) controls one or more videodisc players. The laboratory development system (based on a time-shared minicomputer) is used, primarily for the convenience of existing software tools and hardware interfaces. It is also an example of the computing capabilities expected during the lifetime of the system* . Today, the computing resources required for the Manual can be found in some robust personal computers.

The videodisc players (2) are the laser optical reflective format* . The system uses the videodisc as a general storage medium for pictures, sound, and data. Two players are used in the prototype system, but both are not essential to the system design. The second player was used as an expedient to simplify the prototyping, and most functions could be performed by a single player today.

Sound over still, achieved by using a second disc player, is now available from several manufacturers as a standard option* . Compressed audio can be stored digitally in video frames or compressed in the analog domain for storage and decoding from the audio tracks* . This type of audio eliminates the need for another disc player as a sound source, but raises the cost of the reading station. It also introduces other videodisc mastering costs due to the compressed audio.

Another alternative for sound over still, which was used experimentally in the Movie Manual (see below) and which has become available from several commercial vendors* , is digital audio that does not reside on the videodisc. This could be audio which is digitized onto magnetic storage such as floppy of hard disk, or stored on a CD/ROM. This approach requires that the information for the database (images,

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*In fact, the research began in 1980, before the IBM Personal Computer had been announced. Three to four years later, 32-bit PC's were available commercially.

*Adopted by Pioneer, Sony, Hitachi, Philips/Magnavox, Sylvania, Teac, etc.

*Including Sony, Pioneer, and others.

*From the EECO Corp.

*Such as Visage, Online, and EECO.

sound, text, etc) be distributed on separate media, a common practice in commercial products.

The other feature using two players, visual continuity during disc searches, can be addressed somewhat by disc players with "instant search" (such as the Philips 835, or Pioneer LD-V6000A). These players can search during the vertical blanking interval to within approximately 10 - 200 frames of the frame being shown, without producing a black screen. The addition of a frame grabber, such as the digital television chip by ITT, would also eliminate the need to use a second player as an image source by providing a digital graphic image to mask the search. The problem may eventually be eliminated due to further improvements to videodisc players, systems with built-in realtime video processors, or adoption of all-digital technology.

The output from either of the disc players serves as the input to the digital data decoder (3) which converts data in the video signal to digital form, and passes it to the computer. Error detection and correction are carried out before the data packet is sent to the Movie Manual software.

Graphics and text for the Manual are generated in a frame buffer (4) with 640 by 480 point (pixel) resolution, with a writeable color palette of 512 colors (9 bit planes). Its RGB video output is encoded into NTSC video, then merged with the videodisc image through a television switcher/mixer (5) under computer control. The result is displayed on a standard NTSC video monitor (6). Sound from the videodisc players is routed to loudspeakers (7) at the monitor.

The graphics could have been combined with the video in an alternative manner, by decoding the NTSC signal from the disc into RGB video components, and superimposing the graphics over the video with hardware that operated in the RGB domain. The result could then have been displayed on an RGB monitor. The reasons for superimposing in NTSC are the ready availability of standard hardware (from the broadcast video industry) and the interest in demonstrating the viability of NTSC displays when used to their full capabilities. In practical terms, there is also great potential for devices that tap the economies of scale that are driven by the consumer video markets, but the research was not dependent on that factor* .

Interaction for the Movie Manual takes place at the touch sensitive screen (8) overlaid on the monitor. Additional laboratory devices have supported other experimental variations. These have included a connected speech recognizer, which has been used to try an alternative means of input for some commands, and to combine speech with gestures on the display surface [Gano 83b]. Similarly, a digital audio system, built at the Architecture Machine Group, uses magnetic disc storage to record and playback a reader's "sound notes" at 4kHz bandwidth [Schmandt 81].

A "write once" optical videodisc capable of recording video images is available for storing reader "snapshots" as well (discussed in chapter 4), but was not i tegrated into the Movie Manual system during the research.

3.3.3.2 Implications

Several aspects of this hardware configuration are noteworthy. First, all the components were essentially familiar, standard devices that were available as "off the shelf" items from manufacturers. The distinction about the Movie Manual's use of videodisc technology is that it recognizes the videodisc as a publishing medium. Many other systems have not treated it as such, or have not utilized those capabilities. The Movie Manual was not "predicting the future" with regard to hardware, it simply was using its hardware in a way to realize a new application.

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*Since the initial research on the Movie Manual, consumer NTSC televisions and monitors have evolved dramatically, including such advances as digital picture-in-picture inserts as found in Toshiba or NEC monitor/ receivers.

Second, in the early years of interactive videodisc applications some designers assumed that there was no need for computer graphics on the screen, because of the high quality of the images on the disc. However, the design of the Movie Manual postulates that both the video and the computer generated graphics are necessary, to be combined on the display surface so that each capability is used for the purposes to which it is best suited. In particular, the videodisc is best used as a read-only source of high-quality, real-world imagery with motion and sound. The computer generated graphics, on the other hand, are used for the dynamically updated visual information associated with touch- sensitive graphic controls, interactive feedback, and high-quality text.

Most commercial systems today have incorporated a graphics overlay as a vital part of their display. The touch screen is now common at least as an option at a higher price than the mouse or light pen. But some systems still do not have the quality of high graphics resolution, or a software selectable color palette. Almost none have anti-aliased text fonts. These limitations perpetuate the appearance of "computery" graphics and text displayed in garish, oversaturated colors.

Whether these limitations will be improved will be determined by the collision of several competitive pressures. One is the result of industry trends in the computer graphics field that tend to drive manufacturers of graphics systems to utilize higher quality graphic devices, and the other is the emergence of de facto standard graphic devices that are so widespread that the breadth of their installed base outweighs the quality drawbacks. It is fair to say that there is still no true hardware standard in the videodisc industry after almost ten years of hardware availability.

3.4 Summary

The design of the Movie Manual system is a general purpose approach to the problem of how to create an interactive, multimedia retrieval and presentation system. It proved successful for the implementation of the Movie Manual prototype using the research technology of the day, and it remains valid for newer technological alternatives. It also underscores the accuracy of the Architecture Machine Group vision of the 1970's and early 1980's: the project was developed with the resources that the laboratory believed would be found in personal computers in the near future.

Specifically, these were:

1. substantial computing power via a robust (32-bit) processor and ample memory (1/2 to 1 megabyte per application program)
2. high quality color graphics hardware and software intentionally compatible with NTSC video
3. an X, Y input device (such as a touchscreen)
4. video peripheral devices such as a laser videodisc (and associated audio output), or video camera/digitizer hardware

Over the years, some visitors to the laboratory expressed skepticism that these kinds of resources would be accessible to users of personal computers. If anything, however, the laboratory's predictions actually lagged behind reality: within five years of the first demonstration of the Movie Manual (May 1982), PC-based workstations could be found with approximately the same resources as had been postulated earlier. At present (spring 1988), the latest generation of PC's exceed the prototype's hardware configuration in every respect.

Other aspects of the Architecture Machine Group attitude which were not actually part of the Movie Manual (networked processors, speech synthesis and recognition) are now commercially available for PC's. Even eyetracking may not be far away.

Yet the latest technologies for multimedia delivery vehicles that differ from those of the prototype (such as Hypercard/videodisc, CD/ROM, high capacity magnetic disk, etc) can still be managed with the same design approach. One of the major advantages of the object-oriented programming approach is that the behavior of a particular object class can be separated from its implementation.

For example, the details of how a "movie object" is realized and displayed do not have to be known by the rest of the system for one to be used in or sent a message by another object in the system. Therefore, if a new technology becomes available for the delivery for motion video, it may be incorporated fairly easily into the system by adding new procedures or by modifying those already present for the handling of motion video without disturbing the rest of the system. A movie is still displayed when some object simply sends a generic message such as 'display Movie_3'. The hardware interface, and internal workings of the system may have changed, but it is transparent to the reader, and the rest of the system.

The variations on X, Y input devices can be handled in much the same way. Input points may be entered via different hardware, but to the system there is simply a message carrying an X, Y coordinate pair. The key is in "encapsulating" or confining the device specific details to the object class methods that are responsible for its behavior. Some "authoring systems" for Compact Disc Interactive (CD-I) have already adopted a similar object oriented approach [Canter 86a, Canter 86b]. It remains to be seen in the next few years which techniques emerge as dominant for commercial multimedia systems.

Chapter Four

Results and Directions for Further Work

4.1 Implementation and Evaluation

When discussing results, an issue as major as the relationship of "ideas versus implementation" is the balance of implementation and evaluation. There is first a question of where the effort in a project should be directed; if part of that effort is to go into evaluation of the work in some form, there is then a second question of how to evaluate it.

Historically, there have been various approaches: the strictly quantitative approach of test subjects compared with controls; and more qualitative approach favored by anthropological and ethnographic researchers in which data is gathered that may be somewhat subjective, but nevertheless is a detailed and informative picture of the subject matter. The latter approach presumes that one is looking for something that simply cannot be captured in statistics.

The Movie Manual project had no formal summative evaluation component, for several reasons. First, the approach to evaluation was more qualitative and informal. Second, and more importantly, the prototype being produced was intended to generate feedback as it evolved, so that we could modify and expand it as work continued. As such, it was not brought to a state of completeness and then evaluated, but rather was constantly changing with "rough edges" as programming for new hypotheses was introduced and modified. The work was seen as part of an emerging paradigm.

However, the Movie Manual generated a great deal of reactions. Indeed, review and evaluation took place over almost two years, via a steady stream of visitors to the laboratory whose backgrounds ranged from business and industry, academic research, to blue collar work. While these responses cannot be quantified, we were convinced that that we were seeing a full range of reactions. The broad composite picture showed that the Movie Manual was favorably received. Some of the reactions are included below.

4.2 Results: What we learned -- successes and failures

In general, visitors reacted very positively to the "feeling" of the Movie Manual, and it was an exciting, engaging vehicle for learning. Most accepted the idea that it could be generalized for applicability to many different subjects* . We observed two layers of reactions in people:

1) their judgement of the Movie Manual prototype after a demo, and

2) their quality of engagement during their experience with it.

The more compelling of the two was really the second, as it directly illustrated the genuine interest and absorption with the system. It was an immediate measure of the ability of the interface to draw a user into a "dialog".

Of particular importance to us were the reactions of unsophisticated users(that is, people not from business or the high-technology industry), who would not be predisposed to like or even understand a computer-based system.

One visitor was an automobile mechanic who did routine maintenance on the car of one of the researchers. After getting over the initial novelty of the touch sensitive television screen, he became genuinely absorbed in the alternatives for presentation of information (in the example of the maintenance of the transmission oil pan). He

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*During a site visit in 1982, the laboratory's then-DARPA contract monitor Dr. Craig Fields commented upon seeing the Movie Manual "... of course, this has nothing to do with maintenance."

quickly made the transition from being aware of the technology, to exploring the subject matter and commenting on its meaning to him. This suggests that the style of interface is "transparent" enough to be reasonably unobtrusive even to completely new users. The mechanic also had practical concerns about reliability of any such system "in the field", but he immediately saw a number of uses for a practical system in his own day-today work.

The most successful aspects of the Movie Manual, judging from the reaction of many laboratory visitors, are the dramatic departures from the conventional book's presentations: pages with synch-sound movies, controllable at the touch of a simple graphic symbol. The explorable text (such as the glossary words for example) elicits a strong reaction from almost all viewers, and generates interest in further "Hypertext-style" constructions.

The overall ease of control and detail of interactivity are beyond what most observers have experienced with any other system. Because of their multimedia nature, these presentations are also dramatic departures from typical interactive computing environments. It is these new forms of presentation and interaction that bear the most promise for further exploration and extension.

One of the design issues was how like and unlike a book the Movie Manual should be to provide an easily understood interface. In observing users of the system, we looked for peoples' reactions to the booklike design as a measure of its correctness or usefulness.

It is interesting to consider that the book metaphor seems to have succeeded so well that many viewers quickly acclimated to the Manual's appearance, and even took it for granted. They jumped quickly to the extensions to the book, because they were so different from (what seemed to be) the secure basis of the book facade that allowed them to "get into" the system. While this suggests that the non-book-like effects got the strongest reaction because the book-like parts were easily internalized, it raises a paradox: if you measure what observers like the most, would you conclude that the least noticed parts are the least important ? Are the aspects of a system that are impressionistically most apparent the most effective, or are the least noticed parts that way because they are working so well ?

The results of our observations are ambiguous in a way that may be intrinsic to the situation. It became apparent to us that this is really a fundamental issue of measurement with regard to interactive, multimedia systems. How do you properly study peoples' reactions to such as system ? It is an area ripe for investigation, and some work has taken place in this area recently [Gagnon 87].

The overall high quality in the Movie Manual has also made a strong, positive impression on viewers. It is striking simply because it looks better than displays of other interactive videodisc systems. This is a rather straightforward result of two efforts: first the use of high resolution graphics, a rich color palette, and grayscale text; and second, some attention to graphic design and layout. The latter represents only a minimal effort, and considerably more enhancement of the display can come from continued research (see below). But even a modest amount of effort has produced noticeable results. All of this underscores the need for quality in real delivery systems.

Less visible, but no less successful than the interactivity and presentation quality of the system, is the system's underlying architecture. It has proved to be an excellent framework for prototyping and experimentation. It is a vehicle for the tangible demonstration of new forms of text, graphics, and video. As a result, it is a sounding board for ideas and a stimulant for discussion and further extension. It is also an excellent architecture which lends itself to "technology transfer" for application in the real world of business products (see section 5.2.4).

Not all the hypotheses tested in the Movie Manual succeeded however. For example, one in particular was the idea of generating pre-fabricated pages on a frame buffer for output to film in advance of the pressing of the videodisc. These pages of text and video could be mastered onto a disc, then electronically "mixed" with images from another videodisc to hypothetically eliminate the need for computer graphics in many cases. Aside from several technical problems associated with combining the output of two videodiscs electronically, the pages lacked the dynamic qualities of pages composed and updated on-the-fly from computer generated text and video images. This only seemed to underscore the need for using each image source for what it is intended, that is the disc for photographic quality images, and computer graphics for updateable symbols, pictures, or text.

A second example was the failure of some minutely detailed images from print sources to be useable as still frames on the videodisc (mentioned in section 3.3.2.4). But even those experiments that did not succeed contributed to the quality of the results, and clarified the guidelines for continuing exploration.

4.3 Directions for Further Work

Continued work on the Movie Manual should be concerned with extending the reader's access to and personalization of the contents of the book. This includes 1) global interactivity for easy movement within the book's contents, 2) annotations and other means of customizing the pages for familiarity and ownership, and 3) more "knowledge based" decision making in the system itself.

4.3.1 Global Interactivity

Some aids to global interactivity are already in steady use such as the chapter map overviews in the table of contents, or the "next" and "previous" page flipping symbols on any page. However, much more global information is needed about the resources available in the book. This kind of information could be provided through graphic representations of the quantity and location of the data, using familiar spatial conventions that express powerful organizational principles [Bolt 79].

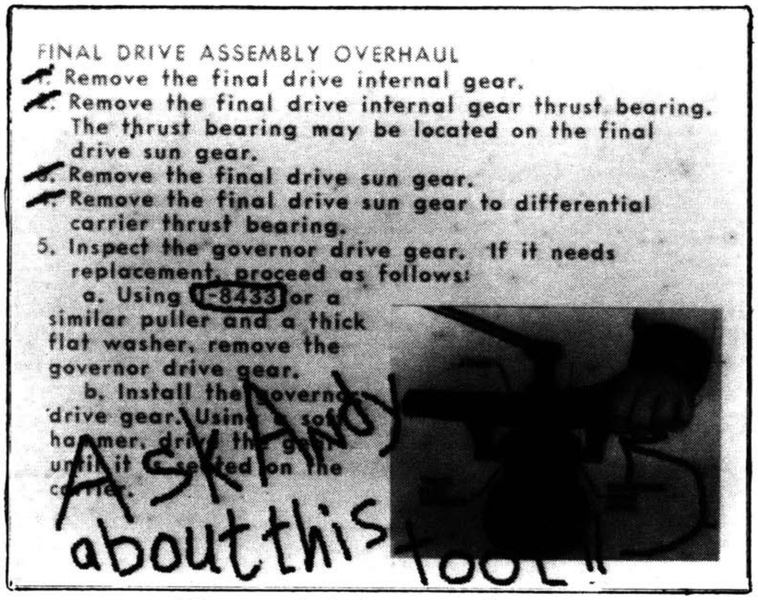
One possible option is a page selection feature that might allow the reader to flip from the current page to any other page in the current chapter. A graphic representation of the pages in the chapter could be displayed, so that a touch to one of the symbols would display the associated page. The same kind of page selection could be available from the table of contents as soon as a chapter region is touched.

Another means of movement throughout the book could be a thumb index along the left- and right-hand sides of the screen. This would serve as an even more global browsing aid, letting the reader jump to different chapters, suggested by graphic "layers" of pages that indicate the size and location of each chapter in the book.

4.3.2 Personalization, Annotations, and Ownership

Personalization of the Manual is aimed at making the reader feel that the Manual is his own copy. There are a number of ways in which this could be accomplished in followup efforts.

A natural impulse, and the first to be included as an option, should be the ability for the reader to "make notes in the margin". Using the touch sensitive screen, and magnetic storage as in the Personalized Movies project, the reader could make hand drawn notes and sketches, text highlights, reminders, comments, even jokes. The system would simply store the hand-drawn notes by recording the X,Y coordinates in a stream and associate them with the current page. Thus, the Manual could be marked up in eraseable "ink", to check off steps in a list, or to jot down questions for later reference (as prototyped in figure 4-1). When no longer useful, the notes could easily be removed.



FINAL DRIVE ASSEMBLY OVERHAUL

Remove the final drive internal gear.

Remove the final drive internal gear thrust bearing. The thrust bearing may be located on the final drive sun gear.

Remove the final drive sun gear.

Remove the final drive sun gear to differential carrier thrust bearing.

5. Inspect the governor drive gear. If it needs replacement, proceed as follows:

a. Using J-8433 or a similar puller and a thick flat washer, remove the governor drive gear.

b. Install the governor drive gear. Using a soft hammer, drive the gear until it is seated on the carrier.

Ask Andy about this tool!!

Figure 4-1: Annotated page

This notion of annotation should be extended to the recording of sound notes, for verbal comments or mechanical noises that are important to understanding a problem. Using magnetic hard disc technology and analog-to-digital conversion for sound, this can be implemented with personal-computer-scale devices [Schaefer 83]. The quality of the sound is a function of the hardware and the availability of storage space for the sampled sound data.

But annotations could be taken one step further with the addition of a compact video camera. The reader could store video "snapshots" on a writeable optical videodisc under computer control to update the Manual with pictures not included in the "first edition", or to illustrate situations not previously encountered. This is yet another technology that was considered experimental at the time of the work on the

Movie Manual (1982), but is now commercially available from Canon and Sony. The cameras are not yet "walnut-sized", as Vannevar Bush once hypothesized (see section 2.1), but they are also not based on a dry-chemical process. It is not unreasonable to expect this technology to become smaller, and less expensive in time.

During the term of this research, there were technical obstacles that made it difficult to add annotations to the videodisc. A write once videodisc was available as a laboratory prototype, but was incompatible with the laser optical reflective discs already being used. The new pictures on the writeable disc would have to be integrated into the data base and accessed through software that made the source of the image "transparent" to the reader.

Figure 4-2:"Write-once" optical video disc player and discs

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Reading a manual may be an often-interrupted process; leaving a bookmark or a "dog-ear" on a page is an easy way to mark the place for later reference, and it can be quickly found upon return. Movie-Manual mechanisms should provide for "picking up

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*photo property Panasonic, Inc.

where you left off", so that pages can be noted with visual dog-ears as personal landmarks, and found quickly by the system on request. Some graphic representation of current dog-ears may be used as a spatial overview of the bookmarks themselves. The reader need never run out of fingers for temporarily holding places, as long as multiple bookmarks can be distinguished.

Another means of personalization could be based on the integration of speech input. Although some progress has already been made in experimental versions, more work is necessary to make speech input reliable. When the reader can speak to the system, he will want to be able to customize his vocabulary, substituting synonyms, shorthand notations, abbreviations, and other idiosynchratic language where he pleases. The capacity for "graceful failure", or handling situations in which it is not immediately possible to respond correctly, by query and test will important, and may also involve speech synthesis in responses [Negroponte 82]. Speech recognition has proven both feasible and useful in other Architecture Machine projects [Pathe 83, Schmandt 81, Bolt 80] and the efforts at speech in the Movie Manual interface should be directed towards that goal. Other research efforts have produced prototype systems using the concept [Vestewig 82, NLM 84].

Lastly, there is the effort at actively involving the reader in the assembly of new pages. Much of contemporary "interactive training" is based on the idea that if a trainee navigates through an "information space", and makes decisions about what to see next, it is generally a better way to learn than just passively sitting through a fixed presentation or "path". An analogy is that personally driving a car through a new environment is often better for learning the layout of streets than just observing as a passenger [Lippman 81a].

But there is an even stronger personal involvement, and perhaps stronger transfer of knowledge when the reader becomes the author through actually assembling the explanation himself, by selecting objects and grouping them to define new, "personalized" pages. Towards that end, the distinction between author and reader has been made intentionally blurry. A reader who becomes familiar with the material can select and reassemble it to taste, using the same authoring tools developed for creating the manual. By examining the alternative components on the disc, the reader can compose new pages that are entered into the data dictionary, and read in the same way as others.

These new pages will "make sense" to the reader because he put them together, and as such, may serve as the best "authored" version of the manual for him. The more a reader uses the manual and reorganizes its contents, the more it becomes attuned to his needs and wishes. But there are still problems in usability that must be addressed:

> Finally, the user interface to authoring tools must be moved from the keyboard to the display, the reader's workstation. Some initial work has been done on graphical tools for perusing the videodisc. But ultimately, all of the methods for creating objects should be as simple and obvious as the methods for displaying them, and should operate in the same speech and gesture domain. An object should be edited by directly changing its appearance on the display, so that the result may be immediately viewed and evaluated. [Gano 83a]

The invention of that interface is as challenging as the development of the Movie Manual's current forms.

4.3.3 Audit Trail and Personal Associations

An "audit trail" which tracks the reader's selections of chapters, pages, etc. would provide a powerful way of summarizing where he has been, and could be used to repeat the path if requested. This recapitulation of connections between related materials may enable the reader to create, name, and store associative trails in the same manner as Vannevar Bush described for linking separate but related pieces of research in his memex. Experimentation is needed to find a suitable means of symbolizing audit trails so that the reader can interact meaningfully with them, and there are questions about how much detail to store to record a reader's activity. But the recording of the reader's progress is certainly feasible, and storing and retrieving such trails as objects should not be difficult* .

A reader will also want to make associative links between material on one page to material on another, and later find these links and use them as a personal index. Other amplifications on traditional indices and overviews suggest themselves: an index that not only lists the relevant pages, but takes the reader to one at a touch; text scanning constructs that perform global searches (as in word processors); or powerful cross-referencing tools that map a word or phrase from one page to other pages in the Manual, as in Hypertext concept (see section 2.3). Techniques for supporting these kinds of information retrieval are now available, in software such as Hypercard (see Appendix B) and others [RMiller 87]. These will be exciting tools with which to survey and digest a book's contents.

4.3.4 System Expertise

It clearly would be better if the Movie Manual had some expert system component added to dynamically find those things that the reader wishes to see; this would provide "automatic authoring" for each individual reader on-the-fly. However, such an undertaking would have made the scope of the research much too broad; it certainly would have improved the system, but in a very real sense it would have been orthogonal to the point of the work: the Movie Manual is an exploration in the context of Media, not in Artificial Intelligence.

But as a follow on to the work, some related goals would be intriguing. An early

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*Hypercard has a built-in trail of previously-seen cards that allows backtracking, and display of the most recent cards as screen miniatures.

goal of the videodisc based training research has been a system which grows to know its user and automatically tailors the presentation to those preferences. Some initial progress was made through explicit query in the Personalized Movies project [Mayer 79], one of the Movie Manual's predecessors (see section 2.2).

Work considered for the continuation of the Movie Manual proposed that the computer would not only "react to user input to alter the presentational style and content directly, but will also monitor the interaction to form a more global model of a particular user's needs, experience, history, and expertise" [Lippman 83a]. This would necessitate a system that must strongly encourage interaction with the user in order to gain information from input. But more importantly, it demands a system that can derive inferences from analysis of interaction to produce heuristics for appropriately personalizing its output.

This would be an ambitious undertaking, which must investigate the state-of-the-art in knowledge based systems and artificial intelligence techniques. But some basic, first order deductions might be made simply: if a reader consistently selects live video sequences over still frames or pixillated alternatives, then that may be construed as a strong preference for live sequences on his part. Off-the-shelf expert systems "shells" and building tools have become common enough that such technology might be integrated with the Movie Manual for further research.

However, occasional changes and varying trends over time will have to be given meaning, and overall the algorithms will likely prove complex. The system may need to maintain a certain element of randomness or surprise, to keep the presentation varied and interesting. The implementation of a system that is even moderately successful in this effort would provide a powerful instructional aid, and a design that would have application to other domains.

4.4 Open questions

The Movie Manual clearly has many directions in which it could continue growing. Because of the focused nature of the work to date, there are several areas that are and will remain open.

4.4.1 Formatting Aesthetics

A medium that depends so strongly on its visual appearance, as does the Movie Manual, requires some advance planning of its graphic layout. However, the initial work was primarily concerned with the development of the user's interaction with the electronic pages, rather than with the graphic design of the pages themselves. Some details of the page layout are determined algorithmically. As a result, there are some unsettled issues related to design and formatting aesthetics.

Several design decisions were made early in the planning stages of the project. For simplicity in the first disc production, there were to be only three formats for the disc visuals: full frame, quarter frame, and half frame. Once produced, the layout on the videodisc was fixed, and the video image could only be displayed in that location, except where still frames were replicated in each of the four quadrants. Mattes for image reduction templates were prepared on the frame buffer in order to maintain registration of the quarter-frame images which were being optically reduced at two different sites* .

Text formatting was somewhat more flexible, but was defined by the capabilities of the existing "Window" software which output text into a rectangular or L-shaped region using one of the eight sizes of the three available grayscale font types. Text could be variably spaced according to the character width, but the inter-line spacing

*This raised numerous problems related to format incompatibility between the 35 mm still photograph frame, the 16 mm movie film frame, and the NTSC video aspect ratio. These kinds of problems seem to be no closer to resolution as new graphics and digital video technologies evolve.

was essentially fixed. Other graphics for the Movie Manual such as movie controls, page flipping symbols, etc. were developed to be as intuitively obvious as possible, compact to fit in the page, and composed of colors suitable for both viewing and video recording. There was a fair amount of variety in the overall appearance, as several researchers experimented with designs and colors.

But generally, the overall *gestalt* of the book is not yet settled, and is certainly an issue to be addressed in any commercial implementation. Design conventions are needed in this new domain for the algorithms which dynamically format page elements for display, and for the tools that might permit the user's easy alteration of those algorithms.

Some answers may come from traditional print and broadcast design conventions. Styles of text justification ("flush right" versus "ragged right"), type setting rules that avoid unsightly placement of words and sentences ("rivers of white space" and "widows"), and workable color schemes are a few of the aspects that will have to be studied and refined to produce a unified and generally acceptable effect.

Ultimately there will be questions about the limits on a user's ability to perform graphic design. The recent wave of "desktop publishing" software has put in the hands of users the tools to do almost anything in the way of layout and design; the benefit of that power in terms of better communication has yet to be assessed.

4.4.2 Adaptability to Instructional Methodologies

Another area that has drawn questions is instructional methodology. There was no detailed study or attempt to determine the single "best" type of presentation (if one exists), and there was no explicit lesson structure of drill and test. In part, this comes from the model of the traditional book, which usually relies on (what are thought to be) clear objectives, well written text, and useful illustrations to convey its information, rather than a rigid regime that forces the reader through a particular way of learning. The approach taken from the beginning of the Movie Manual has been to provide information about a topic in as many different forms as possible -- still frames, live video, text, narration, animation -- and through that variability to let the reader choose the type of presentation that best matches his cognitive style of learning, then view it at his own pace. This is similar to the premise adopted in the Movie Map project which supports the user to "do his own research" [Mohl 81].

Further, the information in a page of the Movie Manual is often presented with a fair amount of redundancy in multiple channels. For example, in a step-by-step movie the verbal narration reinforces what is highlighted in color in the text, and shown in the movie. Questions arise about guidelines for "concept density", timing, use of motion, and other features to insure comprehensibility across a broad spectrum of users.

Some studies have shown, for example, that "redundant information simultaneously presented by the audio and print channels is more effective in producing learning than is the same information in either channel alone" [Hartman 61]. Other data supports the claim that "for specific types of educational tasks, increases in student achievement are directly related to increases in instructional stimuli up to a point beyond which if additional stimuli are added the achievement level of the learners either remains constant or deteriorates" [Dwyer 78].

In her report *Media Research Hit Parade*, Nancy Gulliford outlines the "rules of thumb" which have been distilled from a variety of studies in instructional methodology. With regard to multiple channel communication such as audio/visual media, she notes "the problem in communication efficiency is to reinforce one channel with the other, while minimizing between-channel interference effects" [Gulliford 82]. Her report goes on to suggest rules for duration and grouping of concepts in lessons, use of line drawing or caricature graphics for illustrations, timing for audio instruction, etc. While it is stressed that the variables for effective learning include the nature of the material and the abilities of the learning group, the report's directives for media usage are general and well justified by experimental evidence.

Several of the findings in the report seem to support some of the Movie Manual's approach, such as "if you know you are going to need a mix of stills and motion, the easiest way is with a TV screen... Test results [from study subjects] indicate that the acceptance [by the subjects] will be high" [Gulliford 82]. And although color may sometimes be distracting, it "appears to increase long term memory for peripheral material -- and people like the materials using color better". Simple combinations, following fairly straightforward rules, are best.

Research is continuing elsewhere on the effectiveness of certain techniques in computer generated graphics for training, and it provides sources for information on which to base design decisions [Durett 83]. Testing and evaluation of videodisc based trainers used "in the field" have produced some means of comparing new methods with traditional classroom techniques [Schroeder 82], [Ketner 82] [Vadas 86]. A part of such comparisons is the development of procedures within the systems for testing a student's progress through, and comprehension of, a particular course. Thus, object classes that pose questions and evaluate answers in various ways will certainly be requirements for an operational trainer.

System software might compare a learner's progress with built-in objectives, and suggest additional study or guide subsequent reading. But in devising such software it would be necessary to walk a fine line between guideance and rigidity. So there is ample opportunity for exploration in that domain as well.

4.5 Technology Transfer

One other issue raised by the Movie Manual (and by most research that can be demonstrated in a laboratory setting) is that of "Technology Transfer", that is, of what real use is the new technology, and how well (if at all) can it be transferred to a mainstream production situation ? Answering this question was not within the scope of the Movie Manual project itself, and might not be considered "research" of the same caliber.

But the practicality and applicability of new techniques are some measure of their lasting value. One example of the Movie Manual's impact and usefulness is a software system developed by Mirror Systems, Inc. under direction of the author, which is discussed in section 5.2.4.

Chapter Five

Summary, Applications, and Future

The Movie Manual is part of an emerging paradigm for new media. It is an innovative combination of computing and optical technology which demonstrates the shape an electronic book can take. It demonstrates in prototype form that it is advanced over the conventional book in its modes of use and "software", as well as in its form and appearance.

5.1 Innovations in Function and Form

The Movie Manual has shown the range of forms that are possible from the combination of text, graphics, videodisc images, and sound into dynamic video pages. These new pages validate one of the Movie Manual's fundamental premises, that of making the page the primary means of display, and therefore the backbone of the "book". They are powerful because of the high degree of interactivity available to the user to explore and expand the page's components at a very small "granularity", and to peruse the pages of the book at a preferred pace. In addition, the mastering of digital data at very high density on the discs for the Manual has substantiated the videodisc's value as an easily replicated, publishable entity which contains all the elements required for the electronic book.

But more importantly, the Movie Manual has stressed the contribution of a design philosophy which maximizes the usability of the interface, and makes the Manual an engaging, simultaneous, two-way interaction that is more like a conversation than a lecture. The quality and style of its interaction distinguish the Manual from other systems which may be technically powerful, but misconceived in their design due to omissions in the interface.

5.2 Influences of the Movie Manual

The design approach and techniques pioneered by the Movie Manual have influenced a number of subsequent development efforts, either directly or indirectly. Further, many of its fundamental tenets have been adopted as commonplace in interactive multi-media systems: the use of touch screen for input and control; overlay of computer generated graphics; and even some of the interactive graphic conventions, such as the glossary word in context.

Most of these are research or demonstration prototypes, and not production commercial systems. This raises the question of why business systems have not evolved in the same way. Some possible explanations are offered below, after the examples.

5.2.1 Reconfigurable Video

One effort which the Movie Manual influenced was "Reconfigurable Video", a research system developed by Russell Sassnett for a Master's Thesis at the MIT Film/Video Section in 1986 [Sassnett 86]. The system supports the interaction with *and* the reorganization of video materials via pictorial access schemes that simulate the editing process. One of the primary goals of the reconfigurable video system was to provide a viewer with direct access to video information, using a "table of contents" that provides the options familiar to a print consumer. This replaces the existing "cover-to-cover only" mode of use with a more versatile book-like perspective on the content, which is based on recording and indexing information, and providing database retrieval utilities through a highly visual interface.

In addition, the retrieval of video information from the database was based in part on the object-oriented programming approach described by Steve Gano in the implementation of the Movie Manual [Gano 83a]. One benefit was the system's ability to generate the appropriate action based on a generic request (a message such as 'display A') for different types of data objects. The correct procedure could be deduced by interpreting the type of the named object, so that programming display and interaction were simplified. The resulting Data Dictionary would also be self-documenting, which was attractive for novice (i.e. non-programmer) users.

5.2.2 Microsoft Multimedia Encyclopedia

At the first Microsoft CD/ROM conference (March 1986) [Microsoft 86], the Microsoft Corporation demonstrated a prototype multimedia encyclopedia, which combined pictures, sound, and text in an interactive system that suggested some of the ways in which the CD/ROM could be used. The system, shown in a Microsoft promotional videotape [Microsoft 86], incorporates a number of appearances and techniques similar to the Movie Manual: a page-like screen combining an L-shaped area of text with a quarter-frame illustration, which can become an active animation when the user clicks on a control symbol. Highlighted words in the text can be selected to reveal definitions in rectangular windows that can be removed to reveal the original page.

There is no formal list of references for the encyclopedia tape, or acknowledgements of influences, but the resemblance suggests that the developers of the encyclopedia derived some of the concepts from the Movie Manual work, by then a widely publicized "demo" in the literature [MIT 83] [SIGCHI 83]. Much of the book paradigm is embodied in the demonstration. However, there is no information available publicly regarding its database organization.

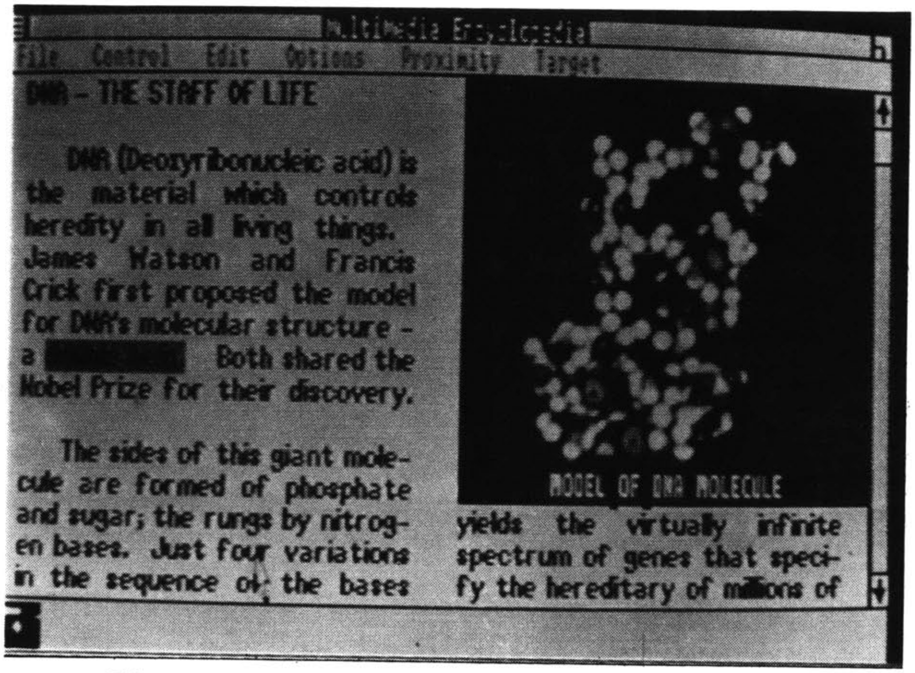

Figure 5-1: Microsoft Multimedia Encyclopedia

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5.2.3 "Palenque" Prototype

At the second annual Microsoft CD/ROM conference (March 1987), speakers from the RCA David Sarnoff Research Laboratory announced their Digital Video Interactive technology (DVI), a multimedia delivery vehicle based on a powerful two chip set of VLSI processors that decompress video information from a CD/ROM (along with audio, graphics, and text) and displayed full motion video. Several prototype applications were demonstrated, one of which was the "Palenque" research experience, developed by the Bank Street College of New York City.

Palenque, as described by Dr. Kathleen Wilson [Wilson 87], introduces middle-school children to the culture and archeology of the Maya civilization of Mexico's Yucatan peninsula, using themes, characters, and locations from Bank Street's

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*photo courtesy Microsoft Press, Redmond, WA (c) 1986

"Second Voyage of the Mimi" television show. The system allows the user to browse through information about a Mayan site at the Palenque site via a simulated "walk" through a rain forest at the site, or in a museum database. Motion video, animations, still images, graphics, text, narration, and sound are all combined in a discovery learning format that lets the viewer choose what to see, when, and where.

Palenque was modeled on a number of predecessors, particularly several from the MIT Architecture Machine Group. These all provide access to information through highly visual menus, such as maps, diagrams, and pictures as well as text. The Movie Manual is cited for its conceptual, rather than spatial framework for organization (as was the case in the Aspen Movie Map, or the Spatial Data Management System), and the Palenque interface incorporates some of the same kind of interaction techniques, such as the topical structuring of information in the Museum setting [RCAtape 87].

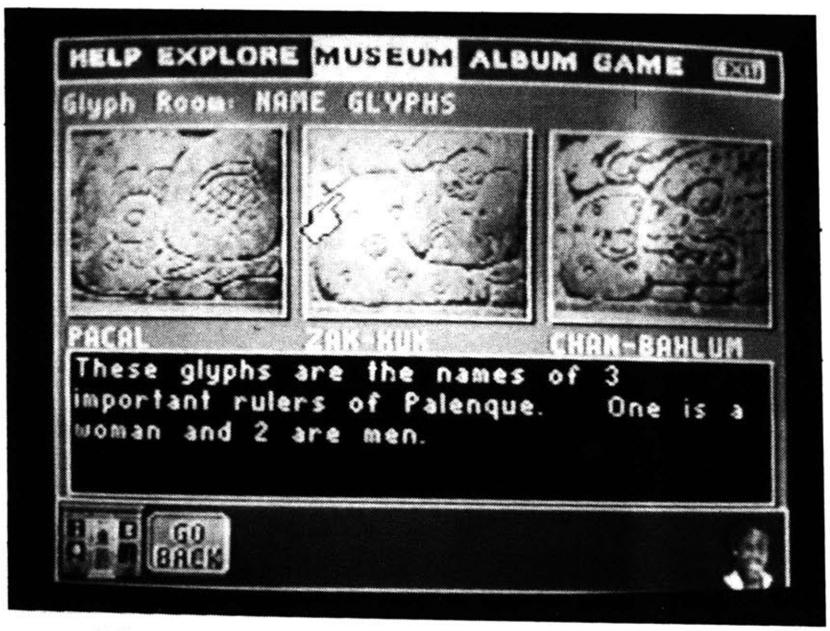

Figure 5-2: "Palenque" demonstration (DVI)

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*photo courtesy Bank Street College, New York, NY (c) 1986

5.2.4 Interactive Videodisc Delivery System, Mirror Systems, Inc.

The design principles of the Movie Manual have been used extensively in the development of a software system by Mirror Systems, Inc. a Cambridge-based electronic-publishing subsidiary of the Times Mirror Company. Under the direction of the author, a system has been created which uses an object-oriented software architecture as the basis for interactive videodisc products*.

The system operates on personal-computer based videodisc workstations with hardware configurations somewhat similar to that of the Movie Manual prototype (see section 3.3.3). The user interacts via a touch sensitive video monitor, which displays videodisc images overlaid with PC-generated graphics and text.

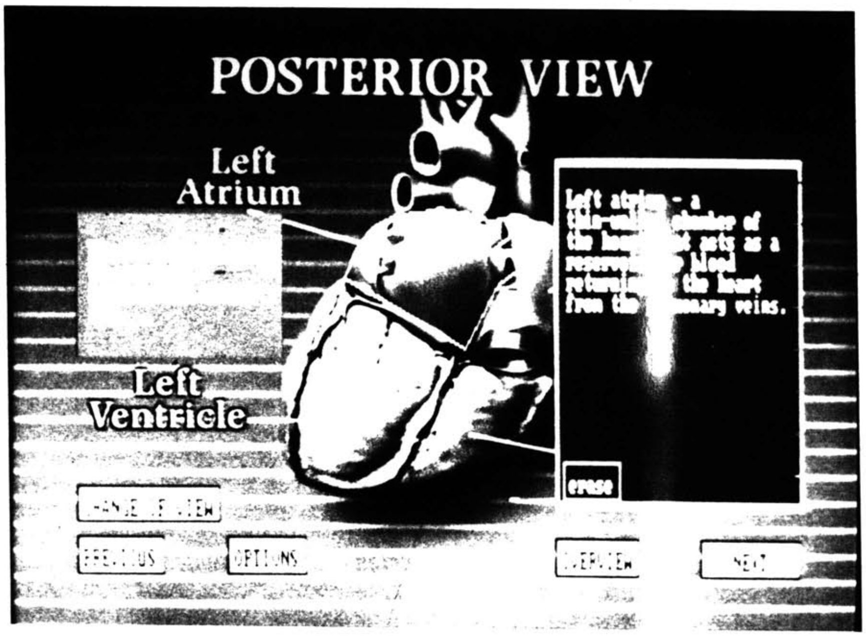

Figure 5-3: Mirror Systems interactive videodisc product

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*Questions may be addressed to the author at Mirror Systems, Inc., 2067 Massachusetts Avenue, Cambridge, MA 02140

*photo courtesy Mirror Systems, Inc. Cambridge, MA (c) 1987

Because it is the basis of a proprietary product, the system cannot be described fully here. However, its use of Movie Manual principles can be discussed.

First: it uses the object-oriented programming paradigm to support a multimedia environment based on distinct object classes that communicate via messages. Elements in these classes include both low-level objects (such as basic movies with sound, text windows, and movie controllers) as well as high-level objects called "templates", which are composed of simpler objects. The templates provide predefined types of presentation behavior, and are similar to Movie Manual objects such as the Step-by-step movie, and others. There are additional types for interactive question-and-answer and testing of the user, and navigation within the course.

The object-oriented architecture has worked extremely well for retrieval and management of data for multimedia objects. Implementation of widely differing behaviors for text, video, or other object types (classes) is "encapsulated" in the procedures (methods) specific to each class. Communication between diverse types is handled well via messaging, because class-specific details are not required. And changes to the implementation for one class can be made without drastic effects on other classes.

The architecture has also worked well for a dynamic development environment in which long term objectives are frequently revised or expanded. It has supported system development by a group of individuals who work fairly independently, but must still integrate diverse pieces of a design into a common system. The result is a system that is compact, modular, and as portable as possible in the real world of commercial software that must operate on a variety of processors and peripherals.

Second: The interface to the system is designed with the same approach to maintaining a high degree of interactivity with different media types (text, graphics, video, and sound). Some examples include touch sensitive glossary words in text;

explorable regions in images; and movie controllers for videodisc movies. Products delivered via the software have generated very positive responses from clients and users.

Third: wherever possible, a commitment to quality of display has been maintained through the use of high-resolution graphics, extended color palettes and grayscale text fonts. As reflected in the design of current products, this has produced very positive reaction from viewers of the system.

It is unfortunate that the display characteristics fall somewhat short of the quality found in the Movie Manual, but most commercial vendors have standardized on hardware configurations that do not support key features found in the Movie Manual.

For example, most videodisc workstations have PC graphics hardware that does not provide the ability to display graphics over the entire screen (but instead imposes a non-writeable "border" area which can only be a single color). Also, many graphics devices do not have sufficient color palette range to correctly display tones for grayscale (anti-aliased) text, and therefore only single-bit text fonts can be used. Another example is touch screens report a touch as an X, Y input point, but cannot report a continuous stream of points to track a user's gesture.

But in general, the Movie Manual's concepts have transferred well to a product-supporting system. It has supported a changing development team which has modified and extended the original foundation with a fair amount of ease, and it appears to be robust enough to continue to be used for years to come.

5.2.5 The limits of influence

As suggested above, the influence of the Movie Manual has been felt primarily on research or demonstration prototypes, and only selectively on product- oriented software systems. There are at least two plausible reasons for this.

The first is the inherent limitations of personal computers up until the about 1984 - 1986. While it has been shown to be possible to implement major amounts of the Movie Manual's features on a standard IBM Personal Computer, there are nevertheless stiff barriers and restrictions to overcome in doing so. The Movie Manual required substantial speed and memory to support the interaction and graphics display. Even compact coding techniques are pushed to the limit in an address space of only 640 K bytes. Performance, especially in graphics output, is marginally acceptable on an 8086-based PC (operating at 4.77 Mhz), and only somewhat improved on an 80286-based "AT " class personal computer (at 6 t 8 Mhz).

In retrospect, an implementation of a Movie Manual style system really requires the speed and memory of at least an "AT" class machine, with considerable amounts of time devoted to developing a kernel of graphics and videodisc support software. An attractive alternative is a MacIntosh II class machine, which comes with more power, memory, and built-in graphics support. The latest round of 80386-based machines, in combination with new "window" oriented interface software, may also offer a richer development environment than PC's of the past.

But a second factor that may have been even more of a deterrent than simply limited machine resources is the lack of programming sophistication in the people who composed training materials. This seemed likely for at least the first half of the 1980's, because most training producers were not experts in computer systems design. Instead, many were Audio-Visual professionals, curriculum experts, courseware developers, or users of existing authoring systems. In fact, National Science Foundation (NSF) funding required that mix of people for some funded work;

innovation in programming technique or style was decidely *not* the goal of most research.

So it may have been that the task of programming an object-oriented system cast in the book paradigm appeared too complex, and other more conventional microcomputer software approaches were adopted. The object-oriented approach of the Movie Manual may sound simple once it is explained, and it *is*, but the Architecture Machine Group also had a substantial base of software resources available to support the implementation of advanced projects, such as utilities for graphics, touch screen input, grayscale text display, multiple videodisc control, and even image digitizing and "paint" packages. For several years after the Movie Manual's appearance, there was little or no off-the-shelf micro-computer software that provided similar functionality for commercial developers.

However, with the advent of new machines and better PC software products, plus the increasing sophistication of competitors in the field, this situation may be changing. Certainly the example set by Apple's Hypercard has generated tremendous interest in (and hyperbole about) the object-oriented programming approach, and in the concept of Hypertext. The "stack" organization model is similar to the book in many respects, and examples of "stackware" are now becoming available. So the ideas may become more popular in the near future.

5.3 Applications

5.3.1 Training

The Movie Manual has clear applications in the field of training. Real investment in interactive videodisc-based instruction has been rising, and numerous efforts that test and evaluate such training systems are aimed at identifying successful implementation strategies [Boerrigter 81, Lent 85]. The systems that generate the most interest and seem to have the most promise for commercial success are those which, like the Movie Manual, can deliver combinations of text, images, and sound with a high degree of interactivity and personalization of format, rather than relatively long video segments with little or no opportunity for control.

5.3.2 Education

The Movie Manual has great potential for similar uses in education -- an encyclopedia with animals charging across the pages, an atlas that lets the reader visit a foreign village, or a medical text that allows a student to look inside a beating heart. It can be a learning aid with the accessibility of a book, the color and motion of television, and the active presence of a personal computer. Whatever form this takes will need to be inexpensive, durable, but most of all accessible to students who can make it a routine part of their learning process.

There have been a number of different vendors trying to establish particular systems as the de facto standard in the educational or institutional market. That place may be taken by the new Apple MacIntosh with Hypercard software providing the basis for a number of new "stackware" applications [Stein 87, ODC 87]. A great deal of agreement still needs to happen before that is true, however.

But the concept of the Electronic Book is extendable beyond just educational forms. The possibilities for what could eventually be "conversational books" on a variety of subjects can be seen in an experimental "artist interview" system, realized with videotape, a microcomputer, and software which allows the user to access the disc by posing simple questions at a keyboard in a quasi-English language form [Bassett 82]. The videotape resulted from several hours of interviews with the sculptor Jacques Lipschitz, and the subject matter of the artist's statements was described in a database.

Questions from the user are examined for key words, and the video segment which is deemed appropriate (according to the software rules) is located and played. The software is not performing natural language parsing language recognition, but it can give the appearance of some limited intelligence by retrieving material related to the user's input. The result approximates the interactivity of a true conversation, but illustrates a responsive system that suggests much more, if it had considerably more sophisticated software.

5.3.3 Interactive Fiction

Another intriguing possibility is the narrative form, that is, an electronic book for storytelling. This storytelling would be more than just enhanced by color, motion, and sound. It could be an interactive process in which the reader influences and even participates in the story.

Much experimentation will be necessary to develop the rules for the visual and conceptual joining of story segments, and the associated constraints on production techniques that may be needed in order to achieve an acceptable perceptual continuity in the story could prove to be complex. Some commercial products have begun to explore this problem* . However, the means of reader interaction is perhaps the largest challenge.

The natural language interface approach to interactive fiction has already been developed in "Deadline", a personal computer based detective game, produced by the Infocom Company of Cambridge, Massachusetts. Deadline is more a new type of novel than a game; it is played through the keyboard of the computer, and is a story composed of 25,000 words of text. Solving the murder case in the story is accomplished by typing imperative sentences, and by varying his input, the reader

*Such as the "Frame-up" interactive detective game from the Imedia Company, 1987.

experiences the story in a different way and from a different perspective each time [Blank 83, Rothstein 83, Symkus 85]. It is a step towards a system which intersects a model of the user's wishes with a stockpile of informational elements.

Invention of new techniques for more fluid and implicit tactile control are required -- as a start, touch sensitive regions associated with portions of the image could be used to direct characters or influence the storyline. But inventing these techniques, and making their mode of use known to the reader will take some imagination. Developments in the voice input/output and bodytracking realms hold some promise. Projects exploring speech and gesture at the interface [Schmandt 81] [Bolt 80] show the power of a simulated dialog. The reader's control through spoken commands, and verbal responses from the system could involve him in the dialog to the extreme at which he could fantasize being in the story himself [Negroponte 79a]. It is this kind of ultra-simulation that may provide widespread consumer entertainment in the not too distant future [Giuliano 84].

5.4 Future forms: changes in technology, politics, economics, and culture

The Electronic Book should evolve with software improvements that make it more intelligent, and technological advances that change its form. This will come from the continuing trend of personal computers to be smaller, faster, and more powerful. Other hardware developments may improve the videodisc, which may become more compact, able to skip thousands of frames during the vertical blanking interval, and capable of storing more sound and video than the current constant angular velocity (CAV) discs. Writable and erasable discs may eventually change the read-only nature of even the consumer products.

But the analog videodisc itself may be replaced with the Compact Disc, a digital storage medium which has already swept the consumer audio industry, and is being used for massive data storage and retrieval applications in its CD/ROM form

[Microsoft 86] [Microsoft 87]. The newest innovations use data compression techniques to put video, or something close to it on a compact disc [Lippman 87].

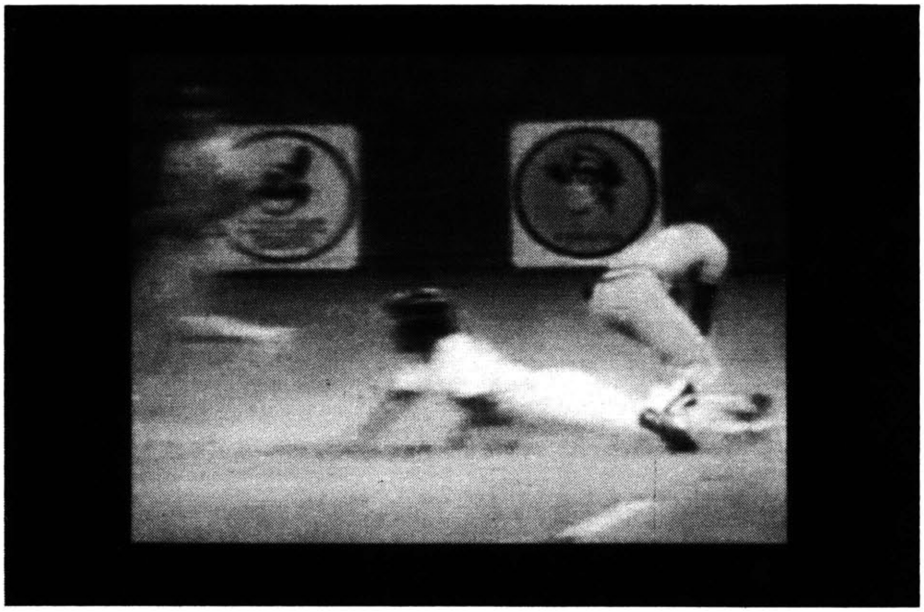

Figure 5-4: Movies on Compact Disc, MIT Media Laboratory

There are various commercial ventures, such as the "CD-I" and "DV-I" formats, along with several other technologies. CD-I is intended to be a consumer entertainment device which is really an appliance with an powerful embedded personal computer [Microsoft 86]. It is a joint effort supported by the Philips and Sony corporations, seen as a standardized delivery vehicle for interactive entertainment and education involving high quality sound, digital images, text, and computer-generated animation. At present it cannot display full-frame, full-motion video images, but several games and "edu-tainment" applications are said to be in development for delivery in late 1988.

DV-I, developed by RCA, is a technology that relies on a powerful set of two VLSI chips to display full-frame, full-motion video, as well as other real-time computer graphics and sound. It was demonstrated at the 1987 Microsoft CD/ROM conference (see section 5.2.3) [Microsoft 87], and has the potential to be adopted as a device for commercial products. However, there are numerous technical and business questions that are not yet answered about DV-I. Considering that there are at last two other means of putting video onto compact disc ("CD-V", and "CVD"*), the ultimate vehicle for doing so may be an as yet unknown format.

Beyond the disc itself, other new features in commercially available components may reflect qualities now found only in laboratory prototypes, such as large flat-panel video displays and high quality voice I/O devices. Further, new means of visualization such as (binocular) stereo video [Roese 79] [Callahan 83] or holographic projection may be commonplace. All these enhancements could make the Electronic Book a fantastically more powerful and engaging medium.

Ultimately, the electronic book should be as portable in weight and shape, and as inexpensive as today's grocery store paperback. If so, it will also need to be at least as dependable (that is, free from failure due to shock, temperature extremes, dust, et cetera)* . One day the electronic book may be something almost anyone writes as a part of the week-to-week personal communication to family and friends [Gano 88]. The means of doing so could be as familiar as the home typewriter, the audio cassette recorder, or the family VCR are today.

However, the future of the electronic book will not be determined solely by technological change. Strong cultural, economic, and political forces are and will continue to be at work that will shape the course that any such new medium might take. These conflicting forces will determine "who controls the cultural technology" [Neuman 88].

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*The first from Sony/Philips, and the second from the SOCS Corporation

*See Appendix C, "Learn with BOOK"

But speculation on forms and formats that seem extravagant by today's standards may appear shortsighted and parochial in only a few years. The Electronic Book may evolve into shapes as remarkable to us as wristwatch television would have seemed to Gutenberg. What matters is that the Electronic Book of the future should be as rich, engaging, and as utilitarian as today's book, and as pervasive.

Appendix A

Experiments in participation in various media

As mentioned in Chapter two, there has been interest in "almost" interactive forms, via experiments in various conventional media. These can be said to be not quite interactive, if interactivity is viewed as follows: *interactivity* can be defined as the quality that allows two entities or agents *to act on each other*, in a mutual or simultaneous one-to-one way. This includes some feedback or acknowledgement of action by each agent within a short time interval, implying a cognizance or recognition of current state by both participants [Backer 83a]. All of this can be epitomized by a conversation. The examples that follow, while creative and engaging, do not fully meet that definition for one or more reasons. But they do serve to highlight how the use of the computer can provide the missing components.

6.1 Participation in print

While books are the most random access and personalized of the types of media being considered, experiments in non-linear narrative or alternative forms of books are rare. Even non-traditional sentence structures and stream-of-consciousness styles are presented in an essentially linear progression of pages.

There are two simple examples (both entertainment) that do not present the material in strict linear fashion, but instead demand that the reader make decisions to determine the outcome of the reading.

The first example is the "Choose Your Own Adventure" series, aimed at children aged 10 and up. Each book in the series is based on a story that is divided into short episodes, one to three pages in length; at the end of each episode there are two (sometimes more) options, offering a decision about what happens next in the plot (see figure 6-1). After making a decision, the reader turns to a page for a new episode, and the outcome depends entirely on the choice made. Some storylines are short (as few as four episodes), while some are over 20 episodes. Because some storylines end abruptly (such as being killed in one of the mysteries!), the reader tends to insert fingers at each successive decision point, until his entire hand is wedged into the left side of the book. This makes "backtracking" one or more steps in the storyline fairly easy. Such a feature might prove popular in a computer-based interactive story.

21

You stare at the priests in front of you. Two of them glare at you. One of them fingers his knife, and suddenly you are frightened.

The head priest smiles at you, and says, "Be calm, we will not hurt you. Look in the heavens. There is Venus. It is both the morning and evening star. Venus will guide you as it guides us. Stay with us and learn about the secrets of the universe. Learn of heaven and hell, learn of the power of the four corners of the earth."

You hesitate but decide to stay with this group of people. Three of the priests move forward suddenly and grasp your arms. They shove you toward the blood-spattered altar. Are they going to sacrifice you? One of them speaks.

"You must make a sacrifice to seal your pact with us. There is no turning back. Here is the knife. You will cut out the heart of the victim."

You are horrified. What is to be sacrificed? Is it an animal or a human, some poor slave or prisoner from a battle? If you say you won't do it, will they sacrifice you?

If you agree to perform a sacrifice, turn to page 34.

If you refuse, turn to page 36.

Figure 6-1: Decision page from a Choose Your Own Adventure story
*

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*From MYSTERY OF THE MAYA by R. A. Montgomery, "Choose Your Own Adventure #11".

While the style and content of the series do not make great literature, the decision point scheme is a clever way to engage the reader in an active role that influences the outcome of the plot.

This structure offers a fair amount of depth; the reader controls the pace of the presentation, and can go back and forth when desired. If the plot is viewed as a tree-structured path, it shows the two or more branches at each decision point, and occasional loop-backs from lower parts of the tree to higher points. The graph shown in figure 6-2 is for "Mystery of the Maya", a 134-page book with 44 different endings. As a structure for information, it works reasonably well; the short episodes could be lengthened, more options added, and the content improved considerably. Ultimately, it still has the limited range of control that such a branched structure dictates.

The second example is really a pair of books for the game "Ace of Aces". This game pits two players against each other as pilots of World War I airplanes, via pages showing various views out of the cockpit, and rules for maneuvering and combating the enemy pilot. The books have sets of facts about the airplanes' behavior, styles, and abilities of different pilots, plus rather elaborate rules for advanced play with special maneuvers. Play begins with both pilots on the same page in each book, which depicts the appropriate view for each pilot; for example, the Allied pilot sees the German plane to his left, and the German pilot sees the Allied plane to his right (see figure 6-3).

The players each select their next maneuver, and by a prescribed procedure, send their opponent to an interim page, which then directs them both to a new common page, showing the change in relative positions resulting from the maneuvers. The object of the game is to position your plane so that your enemy is square in your gunsights. Five "hits" on enemy planes make you an "Ace"; advanced play incorporates dice and tables for calculation of damage done, multi-player combats, and more exotic maneuvers.

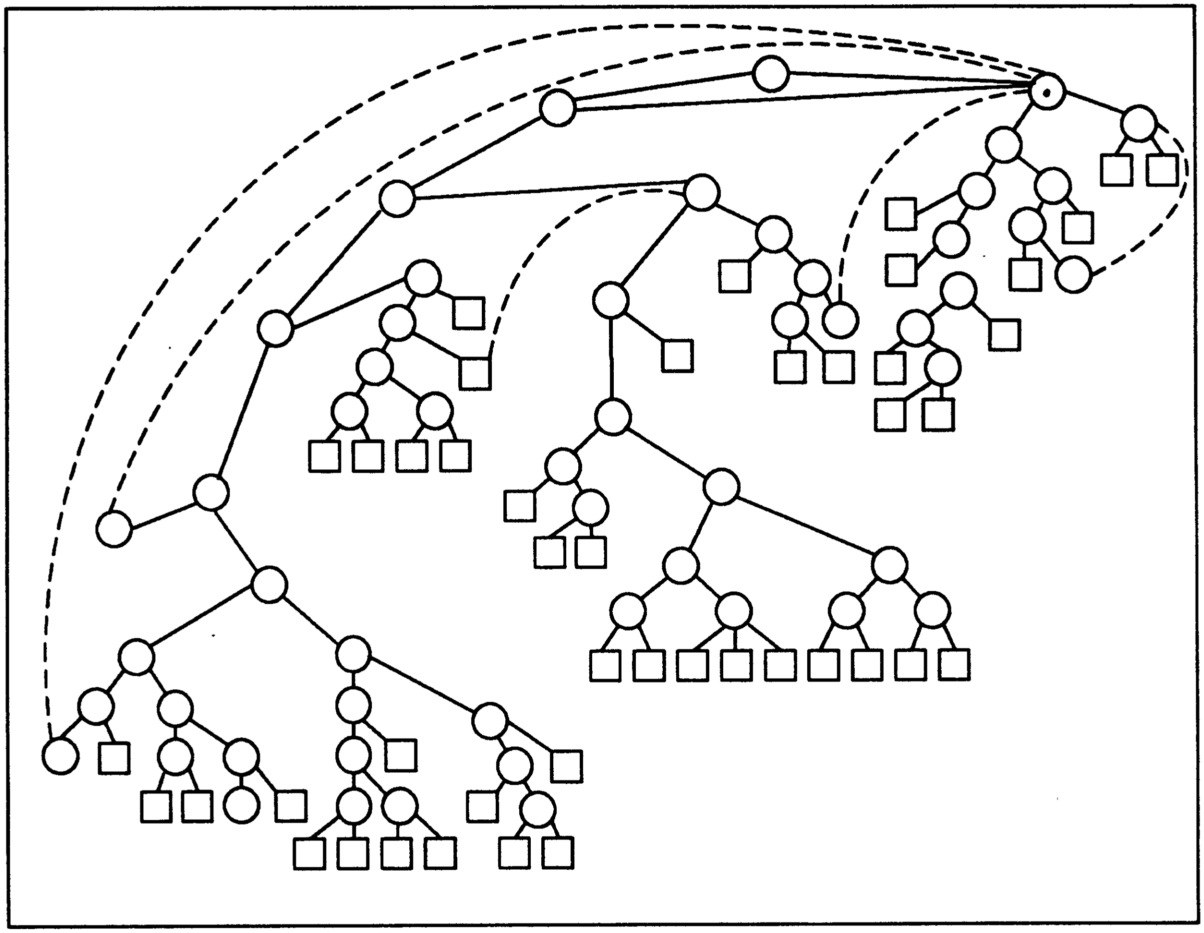

Figure 6-2: Storyline diagram for "Mystery of the Maya"

The game is definitely cast in the format of a traditional book, but in fact is much more similar to the individual frames of a videodisc, laid out in "precomputed" order so that directional maneuvers always cause the two pilots to move correctly relative to each other, and to end on the same page. The procedure is ingenious, and the steps for play are obviously like steps in a computer program and would be amenable to translation into one. There is no sound or explicit motion of course, and in fact no color. But the game is participatory and dynamic in its own way, and can even be played over the telephone. It is the design of the information structures that make the participation possible in print form. The missing element is the local processing power to execute instructions based on the participants maneuvers that

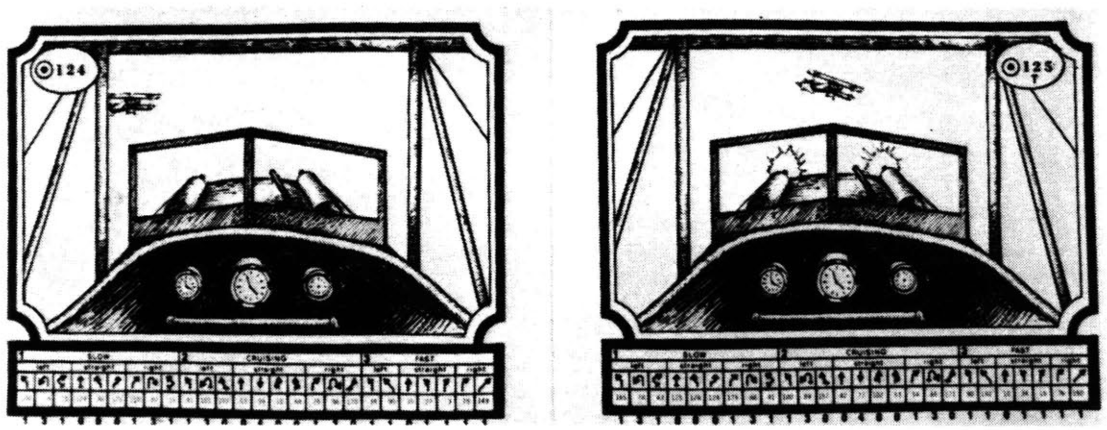

Figure 6-3: Pages from "Ace of Aces" with options for maneuvers

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would bring them to the next "state" or position.

6.2 Participatory television

Several interesting combinations involving television combined with some other medium have made television at least "non-passive" or participatory. The oldest of these was the Jack Barry/Dan Enright children's show "Winky Dink and You" broadcast on CBS from 1953-1958 [Grossman 81], [Fireman 77]. The premise was simple: during the course of the show mysterious "clues" and signs in the form of lines would appear momentarily on the screen, highlighted by arrows, as part of the cartoon world. To participate, kids would have placed special plastic screens on the TV face on which to write the clues in the appropriate colored crayon (some did not bother with the plastic screen, to the financial loss of the marketeers, and the chagrin of the parents). By the show's end, the combined clues would provide an answer to a riddle,

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or a solution to Winky Dink's problem (such as a rope for Winky Dink and his dog to climb down, see figure 6-4).

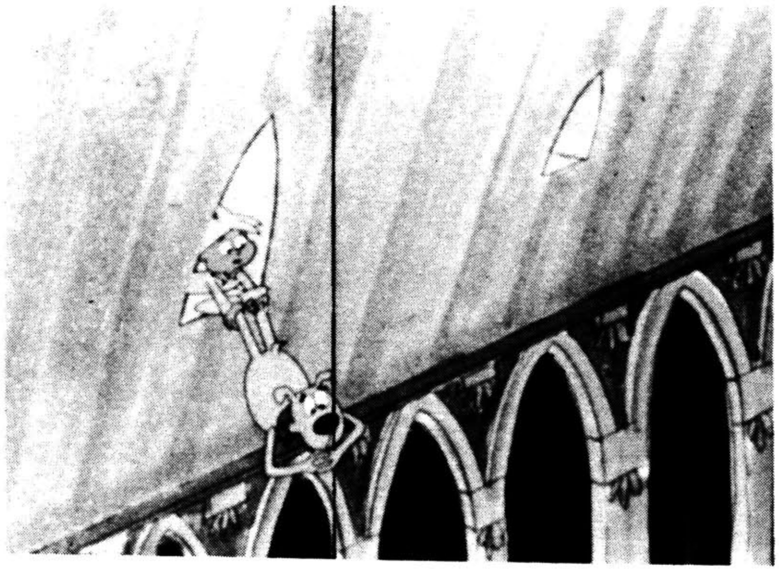

Figure 6-4: Frame showing clue from "Winky Dink and You"

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Although an amusing show, "Winky Dink" was obviously *not* interactive in the true (two-way) sense. It was engaging and participatory for many young viewers, and could be thought of as a whimsical foreshadowing of the touch-sensitive overlay that provides input to truly two-way interactive videographic computer systems, such as paint programs.

Two-way interaction in television is accomplished by combining it with some other medium. One case which may seem trivial is the "phone in" talk show. People televised from the studio are reached by telephone calls from viewers, and the content of the show is largely determined by the viewer's input, one at a time. Of course, the people in the studio typically do not initiate the calls, no computing is involved, and

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*still frames from "Winky Dink and You", property of Barry & Enright Productions, Los Angeles, CA the studio portion of the program is "live", but this relationship might serve as a model for other applications.

Another type of two-way communication in television is the interactive cable system, such as Warner-Amex's "QUBE" (TM) system in Columbus, Ohio. Home television receivers are actually at the end of a computer controlled cable system which provides viewers with broadcast programs and a pushbutton keypad for input. Viewers tuned to a particular show may be polled at certain times to respond to questions or text menus displayed briefly on the screen. This technique has been used for opinion polling on current events, "teleshopping" from broadcast advertisements, round-by-round scoring of boxing matches, and on at least one occasion for an "interactive television drama" called "The Adventures of Lulu Smith"* .

Here a one hour comedy drama was periodically halted, and several options for plot alteration were displayed on the screen for ten seconds. Each time, the audience voted via the 5-button home keypad to determine the direction that the plot would take next(see figure 6-5). About two-thirds of the program was prerecorded, and the remainder was performed live in a studio. The prerecorded segments included different plot options, aired depending on the audience vote. The decision points, however, were only offered a few times during the show, with between two and five alternatives each time. So the story line was even less complex than the "Choose Your own Adventure" stories described earlier, but there were some alternatives that could provide variability.

While QUBE is a two-way communication, it remains a polling at select times of many viewers with only a limited range of options for variation. As such it is not truly interactive in the sense of providing interruptibility for the viewer, nor is it ever one-

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*produced by WGBH New Television Workshop, Warner-Amex Cable Communications, Inc. in association with WOSU TV34 at the Ohio State University, and Connecticut Public Television

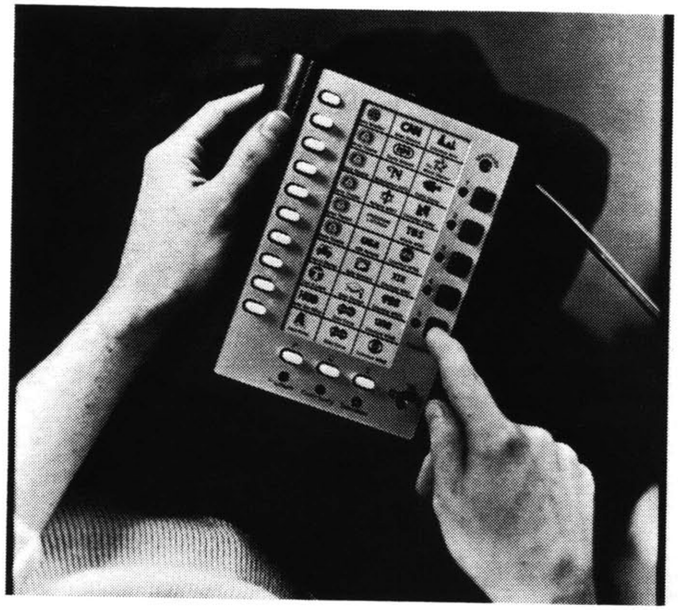

Figure 6-5:QUBE two-way cable keypad
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to-one. Commercially speaking, the QUBE venture was not a great success.

The consumer videodisc player made possible some quasi-interactive home entertainment, such as "The Mystery Disc" and "Mystery Disc II". These are detective stories which allow the viewer(s) to make decisions at various points which affect the outcome of the plot. The interaction was via the remote control keypad for the Level I player, so all decisions are essentially selections from multiple-choice menus.

More recently, new kinds of interactive television have appeared, including videotape-based games and broadcast shows. Backed primarily by game and toy manufacturers, some involve video-arcade-style electronic input devices that allow the participant to "shoot" at targets on the screen (Mattel "Captain Power"). But others control electronic toys with sensors that will react to commands sent during the broadcast (Mattel "Axlon"). Still others allow the viewer to alter a presentation from

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*photo courtesy Warner-Amex QUBE

special videotape with four parallel channels of information (Hasbro "WOW") [Purdy 88].

6.3 Viewer participation in film

Motion pictures are typically linear presentations of picture and sound with no opportunities for the viewer to change or digress from the predetermined plot. This has been true for the eighty to ninety years that movies have existed.

Experimental filmmakers have altered the content and the images, and even the traditional sense of time. Chris Marker's "La Jete" (1963) is exclusively still images (with one glorious exception) with voice-over narration, and travels forward and backward in time [Stephenson 65]. "Last Year at Marienbad" (Alain Resnais, 1961) is well known for its reshuffling of scenes, narration, and segments of time. Wojciech Has' "Saragossa Manuscript" (1965) nests stories within stories within stories, intertwining the lives of the characters in time and place. Yet all of these films are still presented in a linear fashion from start to finish, with the audience watching passively, unable to alter the outcome.

This tradition of linearity in film makes the Czechoslovakian film experiment "Kino-Automat" rather significant. Developed as a World's Fair pavilion for Expo '67 in Montreal (and repeated at the Hemisfair of 1968 in San Antonio), the Kino-Automat was the first rudimentary interactive movie theater [Bryant 68] [Cronkite 68]. The audience watched the movie from specially equipped seats with two pushbuttons; the storyline halted at five key points and the audience was asked by the Kino-Automat hosts to vote quickly on which of two alternatives would happen next. The votes were counted electrically, and one of the two sequences would be shown, based on the results (see figures 6-6, 6-7).

While this would appear to imply that there were 32 different stories that could

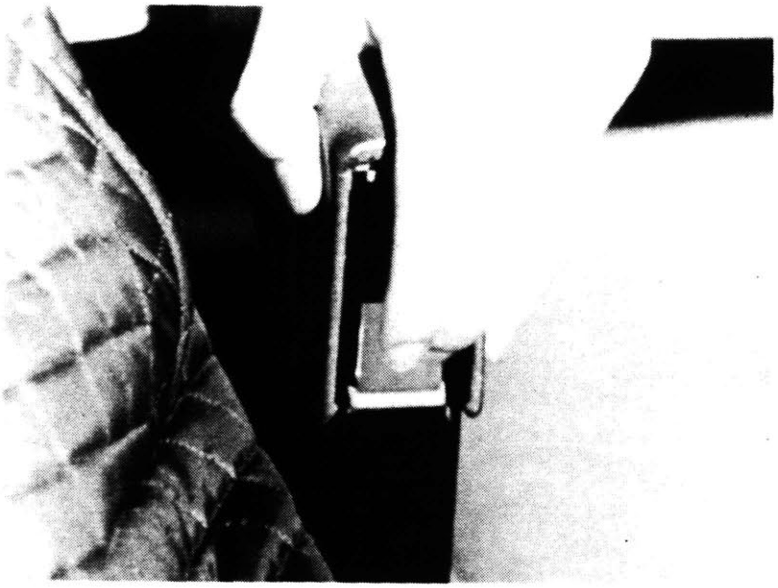

Figure 6-6: Voting buttons in Kino-Automat

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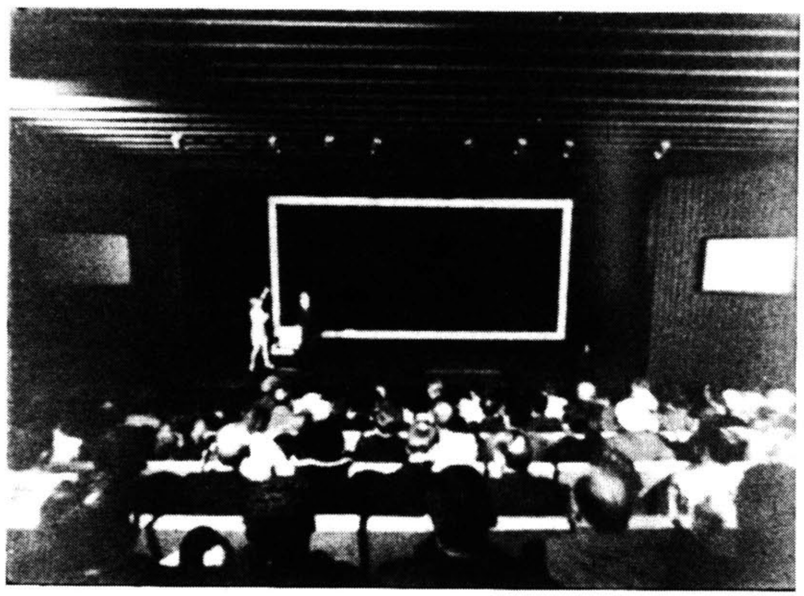

Figure 6-7: Tally board in Kino-Automat

*

occur, that was not the case [Naimark 82], [Casell 83]. Each alternative sequence

*still image from "The Shape of Films to Come", courtesy CBS News, New York NY (C) 1968

*still image from "The Shape of Films to Come", courtesy CBS News, New York NY (C) 1968 appeared to proceed in a unique way, but instead "converged" by remarkable coincidence, to the same situation reached at the next decision point by the other alternative. In fact, after the movie ended, the hosts asked the audience what would have happened if the choices had been made differently, then cleverly explained how the same inevitable results would be reached. While this may have been a fatalistic philosophy, it was more likely a technical necessity as well because of the technology of film and projectors. Managing the number of segments of film for a binary-tree-like storyline, compounded by the the more than 1500 showings of the Kino-Automat film, would have been nearly impossible. So, there were effectively only two linked projectors, with an alternating lens cap [Naimark 82].

The concept of the Kino-Automat still serves as a useful motivation for the development of interactive stories, expanded to be interruptible at all times and for an audience of one; this goal may be realizable through the new medium of a computer augmented with a videodisc.

Contemporary research by Gloriana Davenport at the MIT Film/Video section (in collaboration with Project Athena) uses interactive computer systems and optical videodiscs in order to provide a viewer with an explorable reservoir of motion video and other documentary film materials. The intent of the work is to develop methods for "the interactive delivery of cinematic case studies" [Davenport 87]. The viewer is no longer just a "passenger" watching the documentary film, but more a "copilot" in navigating through the materials, and can take notes, explore particular subjects, and form personal opinions as result of the individualized "itinerary" along the way [Altman 88].

6.4 Spectator involvement in art

There is usually a firm distinction made between art and communication media. However, some of the same conditions that have been discussed in previous sections apply to art as well. Art as "a means of expression" (Webster) has a long tradition of being experienced passively in a one-way manner, but it has had some notable experiments which involved the spectator in the determination of the form and behavior of the art.

During the period of the 1960's and 1970's, interactive art/ performance environments were explored in a wide variety of forms including written text, film, video, lasers, sound, etc. by artists such as Allan Kaprow, Nam June Paik, and others [Davis 73]. The fundamental relationship of the viewer as a passive observer of an object (painting, sculpture, etc.) was changed to incorporate the viewer as a participant in direct experience with the work, as in James Seawright's ***Electronic Peristyle*** (see figure 6-8). Described by Davis, "As spectators enter the space, they activate the columns to produce varying light. sound, and air patterns". The sculpture's activity was determined by the changes in the environment due to viewers in a two-way, real time manner. The exchange was not one of text or pictures, but it captured the qualities of a responsive interface in a simple, immediate way.

6.5 Audience participation in theater

Although theater is not a mass medium in the modern sense, it is an art form that is one of the first organized forms of storytelling, and perhaps indirectly, of instruction. Experimental theater groups have tried to alter the passive role of the audience by involving its members in the performance in some way. In the late 1960's, followers of Antonin Artaud created the "Living Theater" which uses confrontation and improvisation to engage or goad spectators into becoming active participants in the action [Monaco 77] [Hopkins 80]. The content of the performances depends on the

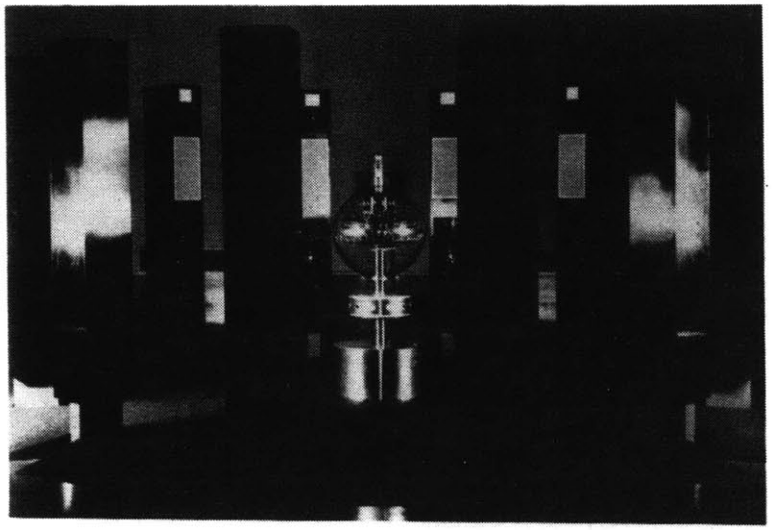

Figure 6-8: James Seawright's *Electronic Peristyle*, 1968
*

interaction of the audience members with the cast.

A recent improvisational production called "Theater Invaders" is interesting because it is modeled on an interactive videogame, with elements of a television gameshow included [Engstrom 83] [Schwartz 83]. The audience controls the action on stage by deciding questions posed periodically by the actors; the play is divided into five 20-minute "rounds" of increasing "difficulty", that is, having more catastrophic or improbable dilemmas. Given a standard initial situation, the actors receive general scenarios of what may happen in each upcoming round. But when an "invader" interrupts the action in the form of a telephone call, doorbell, etc., one of the actors calls out to the audience for a fast decision on some alternatives. The actors must then improvise their actions, no matter how ridiculous the situation, based on the audience's response. Approximately forty invaders appear in an evening, with occasional surprises to guarantee spontaneity.

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*Reproduced with permission, Douglas Davis

The form for interaction is flexible, since the plot segments are predefined in only a very loose way, and the responses of the actors can be inventive within the confines of the audience's decision. "Theater Invaders" takes some of the traditional elements of the theater and combines them with the dynamics of an arcade game to produce a new form of entertainment that involves its viewers as essential controlling elements. Ultimately, however, the theater is not the one-to-one relationship of a conversation, and even frequent polling by the actors does not provide small enough "atomic units" for real interruptibility and control by the single audience member.

Appendix B

Apple Computer's "Hypercard" software

In August of 1987, Apple Computer announced a new software package called "Hypercard", which is now being shipped free with every new MacIntosh computer. Hypercard is based on Ted Nelson's original concept of Hypertext and Hypermedia (see section 2.3), and it is intended to be used to construct "documents" that include text, graphics, sound, and even video.

But more importantly, these documents may be "non-linear" in the sense that the reader need not move through them by always going from the beginning straight through to the end, but rather may go from one point to another by selecting active fields or "buttons" that are embedded in the pages. The buttons are a means of associating some concept or image in a document with another concept or image in that document or some other document. This provides a means of developing a highly interconnected web of information that may support everything from conventional work accessories such as a rolidex or calendar, to technical documents that provide links from a biblio- graphic reference to the original text of the reference.

Hypercard comes with not only prefabricated buttons and icons, but with HyperTalk, a language that allows a user to define the behavior of a button. There are capabilities for generating graphics and sound, manipulating the database, and driving peripheral devices, all via the "scripts" that user writes [Goodman 87].

Hypercard is intended to provide a non-technical user with a "software erector set" (as described by creator Bill Atkinson) that can be used to create sophisticated interactive applications. It is seen as being usable as an interface construction kit, since it provides interactive symbols and associated actions, and also as a data organization system in which a designer can construct fields within records, create structures of records, etc.

Hypercard is significant for at least two reasons: first, for its accessibility. As software that is being distributed and supported on every new Macintosh (and available for upgraded Macintoshes at low cost), it is rather quickly creating a large installed base of owners, and therefore may well develop as a widely used and familiar utility for many people. Because it is is being promoted as a tool for non-technical people (non-programmers at any rate), it comes with ready made examples of Hypercard "stacks" or applications to learn from and emulate.

One way to assess Hypercard is to study some of the example applications that have appeared thus far. The earliest of these were shown at the announcement of Hypercard (the August 1987 MacExpo in Boston) in a presentation led by Dr. Kristina Hooper. It included demonstrations based on Hypercard and videodiscs developed by Grolier's Encyclopedia; WGBH Television and the National Geographic Society (using Nature discs); Walt Disney Enterprises (using "Donald Duck in Mathemagicland"): and a historical research survey depicting the "roots" and major milestones of the interactive multimedia field (S. Gano and F. Floren). Another is the "Shakespeare" project developed by Prof. Larry Friedlander which teaches both Shakespeare and the theater via an interactive Hypercard program.

As a result of a development consortium supported by Apple, Hypercard is also part of products being developed by third party vendors, for example in educational packages using interactive videodiscs [Stein 87, ODC 87]. These low cost applications (under $100 without videodiscs) may accelerate the familiarity of Hypercard even more.

All of these Hypercard stacks are highly engaging, and show the potential of Hypercard as a vehicle for creating powerful and exciting communication forms.

However, as with any software product, there are areas in which Hypercard may, at least initially, still have room to evolve. At the very least, Hypercard is new, and is undergoing the usual period of debugging; Bill Atkinson has said that he considers Hypercard about two-thirds finished [Rospach 87]. Presumably this is a measure of the enhancements that can be added to an already multifacted and versatile system, and is not really an issue.

There is also a lack of overlay for color graphics and text onto videodisc images. Presently a Hypercard application that uses a videodisc must have two separate screens, one for graphics, and one for video. This is in contrast to a number of existing interactive video systems which have had color graphic overlay for some time. There are already companies addressing this situation with soon-to-released hardware [Nunnes 88], so it may also be a momentary inconvenience for those who wish to develop applications which combine graphics and video.

There are other technical questions that affect the user, such as the apparently large storage size of Hypercard stacks. While memory and disk storage get larger and cheaper each year, this may still be a problem for an ambitious project that encompasses vast amounts of subject matter. The solution may lie in use of CD/ROM, high-capacity magnetic (eraseable) disks, or the standard videodisc. The use of the Hypertalk language for defining button behavior, etcetera has only been under exploration for a short while.

But the longer term questions have to do with Hypercard's real usability by non-programmers, and the effort required by a user to create and "publish" a Hypercard stack. The first offerings have been interesting and inspired, but to construct a truly well-interconnected (but enormous) "Hypermedia" database may require a great deal more work than some authors can produce routinely. Computer software developer Mitch Kapor has called Hypercard (and other new products) "mysteryware" because its supporters and even its developers cannot exactly explain why it is so powerful

[Kapor 88]. Though enthusiastically received by many in the software/technical community, Hypercard has simply not been available for long enough to a large population of non-technical users to know many of the answers yet.

But clearly, the net effect seems to be that Hypercard is a dramatic announcement by Apple that could be as portentious as the announcement of the original MacIntosh itself. It is a breakthrough that has happened after twenty years or more of experiments in the field by various researchers, and leaves opportunities for more. But its use must go farther; as stated by Dr. Kristina Hooper:

> Yet even with these explicit examples, multimedia experiences have seemed to be stuck in the imaginations of researchers and in the special environments of flourishing research laboratories [Hooper 88].

Hypercard's real impact cannot be felt until it has reached and has been understood by a large number of people in the general populace.

Appendix C

Learn With BOOK

"Learn with BOOK" by R. J. Heathorn, from *Punch*, May 8, 1962.

A new aid to rapid - almost magical - learning has made its appearance. Indications are that if it catches on all the electronic gadgets will be so much junk.

The new device is known as Built-in Orderly Organized Knowledge. The makers generally call it by its initials, BOOK.

Many advantages are claimed over the old-style learning and teaching aids on which most people are brought up nowadays. It has no wires, no electric circuit to break down. No connection is needed to an electricity power point. It is made entirely without mechanical parts to go wrong or need replacement.

Anyone can use BOOK, even children, and it fits comfortably in the hands. It can be conveniently used sitting in an armchair by the fire.

How does this revolutionary, unbelievably easy invention work ? Basically BOOK consists of only a large number of paper sheets. These may run to hundreds where BOOK covers a length programme of information. Each sheet bears a number in sequence so that the sheets cannot be used in the wrong order.

To make it even easier for the user to keep the sheets in the proper order they are firmly held in place by a special locking device called a 'binding'.

Each sheet of paper presents the user with an information sequence in the form of symbols, which he absorbs optically for automatic registration on the brain. When one sheet has been assimilated a flick of the finger turns it over and further information is found on the other side.

By using both sides of the sheet in this way, a great economy is effected, thus reducing both the size and cost of BOOK. No buttons need to be pressed to move from one sheet to another, to open or close BOOK, or to start it working.

BOOK may be taken up at any time and used by merely opening it. Instantly it is ready for use. Nothing has to be connected up or switched on. The user may turn at will to any sheet, going backward or forwards as he pleases. A sheet is provided near the beginning as a location finder for any required information sequence.

A small accessory, available at trifling extra cost, is the BOOKmark. This enables the user to pick up his programme where he left off on the previous learning session. BOOKmark is versatile and may be used in any BOOK.

The initial cost varies with the size and subject matter. Already a vast range of BOOKs is available, covering every conceivable subject and adjusted to different levels of aptitude. One BOOK, small enough to be held in the hands, may contain an entire language learning schedule.

Once purchased, BOOK requires no further upkeep cost; no batteries or wires are needed, since the motive power, thanks to an ingenious device patented by the makers, is supplied by the brain of the user.

BOOKs may be stored on handy shelves and for ease of reference the programme schedule is normally indicated on the back of the binding.

Altogether the Built-in Orderly Organized Knowledge seems to have great advantages with no drawbacks. We predict a big future for it.

Appendix D

Acknowledgements

I had help from a lot of people during this work. I hope to thank everyone in person, but I want to mention certain people here.

First is Alyce, my wife. She has been through it all with me, and I couldn't have made it without her. It's impossible to say what her support has meant. I feel very lucky to have that.

Andy Lippman has been my advisor, committee chairman, and the principal investigator for the Movie Manual project from the start. Andy's combination of intense drive, technical expertise, and maniacal sense of humor have made working with him a truly unique experience. MIT and the project would not have been the same without him. I say sincere thanks for the support and energy over the years.

Seymour Papert has helped me tremendously during the past year or more by working with me to make my writing clear, and the results of the project meaningful. In the process I have learned a lot about his work and what he has done for other people, and I am even more impressed than when we began.

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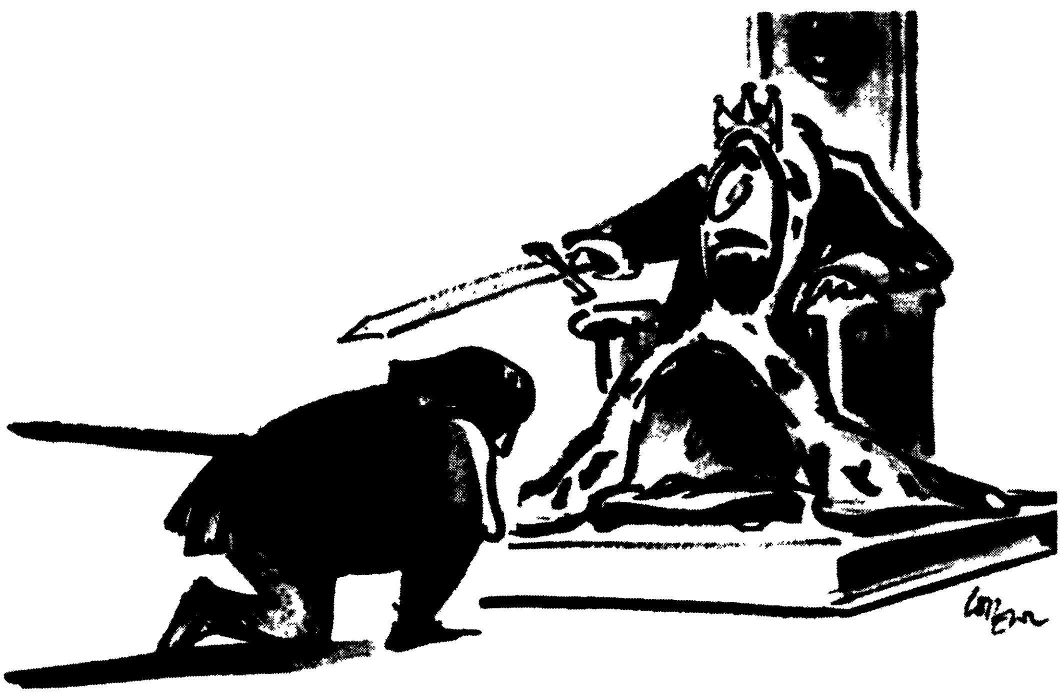

"My son, you have survived the ordeal by fire and the ordeal by water. You now face the final challenge—ordeal by media."

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*Reproduced with permission: Drawing by Lorenz; (C) 1982 The New Yorker Magazine, Inc.

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