# Hypermedia and Laserdiscs: Controlling and Structuring Multimedia

**Brian R. Gaines**

*The University of Calgary*

*Medium: an intermediate agency, means, instrument or channel,*
*Hyper: over, above, beyond (Oxford English Dictionary)*

## ABSTRACT

The combination of computers and laserdiscs offers a new medium with exciting potential for many areas of application. This paper gives an overview of the technology, its state of development, criteria for its usability, and a projection of future developments.

## INTRODUCTION

The computer control of laserdiscs offers obvious possibilities for enhancing the medium and its applications:

- The computer can store additional graphics, text and sound.
- Computer graphics can be overlaid on laserdisc graphics.
- The computer data is variable, not static - it can be updated and generated dynamically.
- The computer can offer a wide range of retrieval modes going beyond direct addressing.
- Indexes, hypermedia links and context-sensitive access can be generated.
- The user interface to the disc can be user-and domain-specific, tailored to the application.
- The material on the disc can be combined with other material to form an integrated application.

There is a wealth of literature on interactive multimedia combining computers, laserdiscs, CD-ROMs and other media (Ambron & Hooper, 1988). The possible applications in industry, government, education, medicine, entertainment, and so on, are beyond most of our imaginations. We are witnessing the birth of a new medium with as much potential for social change and cultural and intellectual impact as any before it. This paper focuses on the practicalities of bringing this new medium into use.

I have deliberately used the world "potential" in the previous paragraph - some may argue that the computer age is already here - I think not. Computing is still an immature technology; its control is still in the hands of the specialist few; until it is as natural and easy to "program" the computer as it is to speak, write

and draw, only a minor part of the potential of the new medium will be realized. Professional skills will be as important to the computer medium as they are to the applications of other media, but what will be needed are the creative skills to project one's visions into the medium - not the technical skills to crank the medium into being.

Thus, new developments for controlling and structuring multimedia, such as hypertext and hypermedia, should not be regarded as yet another technical innovation offering more functionality. Instead, one should ask: "How does this help to bring the medium under creative control?" "What can *I* do with it to achieve *my* goals - as an artist, an educator, or a clinician - *not* as a programmer." Indeed, the bottom-line question for any software innovation should be, "to what extent does it make 'programming' easy and natural for those who are not computer specialists?"

Much of the hope, and the claims, for hypermedia systems such as Apple's (1987) HyperCard and Brown University's IRIS Intermedia (Meyrowitz, 1986; Yankelovich, Landow & Heywood, 1987) has been that they deliver the power of computer-controlled multimedia to end users who are not computer specialists. This paper analyzes what is involved in doing this, how much has been achieved, and what developments are under way.

## WHAT ARE HYPERTEXT AND HYPERMEDIA?

The concepts behind hypermedia can be traced back to Vannevar Bush's article in 1945 entitled *As We May Think*, which called for a major post-war effort to mechanize the scientific literature and support associative linking:

> *The human mind...operates by association. Man cannot hope fully to duplicate this mental process artificially, but he certainly ought to be able to learn from it. One cannot hope to equal the speed and flexibility with which the mind follows an associative trail, but it should be possible to beat the mind decisively in regard to the permanence and clarity of the items resurrected from storage.* (Bush, 1945)

The technology in Bush's time was not equal to the task; it was not until 1963 that Bush's vision was regenerated by Douglas Engelbart in a paper entitled *A Conceptual Framework for the Augmentation of Man's Intellect*, in which he suggests a new stage of evolution characterized by "automated external symbol manipulation" supported by computer technology:

> *In this stage, the symbols with which the human presents the concept he is manipulating can be arranged before his eyes, moved, stored, recalled, operated upon according to extremely complex rules - all in response to a minimum amount of information supplied by the human.* (Engelbart , 1963)

Ted Nelson is generally credited with coining the terms "hypertext" and "hypermedia" for the richly associative information storage and retrieval systems consistent with Bush's and Engelbart's visions. His *Xanadu* hypertext system design provides for a massive corpus of documents worldwide to be linked associatively in an information network supporting scientific and literary creativity and the associated critical commentary, refereeing and royalty arrangements:

> *The* document, *our fundamental unit, may have windows to any other documents. The evolving corpus is continually expandable without fundamental change. New links and windows may continually add new access pathways to old material.* (Nelson, 1980)

Hypermedia extends the concept of richly linked textual material to all forms of material that may be digitally encoded for storage and retrieval through computer-based systems, including images and sound. Figure 1 shows a typical hypermedia configuration. The various subsystems are:

## HARDWARE SYSTEM

- microcomputer
- graphic display screen with a fairly high resolution for computer text and graphics
- television display screen for laserdisc and CD-ROM pictorial output, possibly with the capability to superimpose computer text and graphics
- speakers or headphones for laserdisc, CD-ROM, and computer audio output
- keyboard for text input
- mouse, and possibly touchscreens on the displays, for pointing and graphic input

## INFORMATION SYSTEM

- magnetic disc for variable data in the hyperbase, text, graphics and associative links
- laserdisc for fixed data including movie and still pictures, sound, text and graphics
- CD-ROM for fixed data including movie and still pictures, sound, text and graphics

## SOFTWARE SYSTEM

- hyperbase index providing an annotated list of everything on the storage media
- hyperbase map providing pictorial access to everything on the storage media
- hyperbase linkage using the index, map, and link structures to navigate the stored material
- perspective generation helping the user to combine material to build new accesses to the stored material
- video selection indexing and control software for the image data stored

- audio selection indexing and control software for the sound data stored

## COMMUNICATIONS SYSTEM

- networks, local and remote, allowing access to other information systems

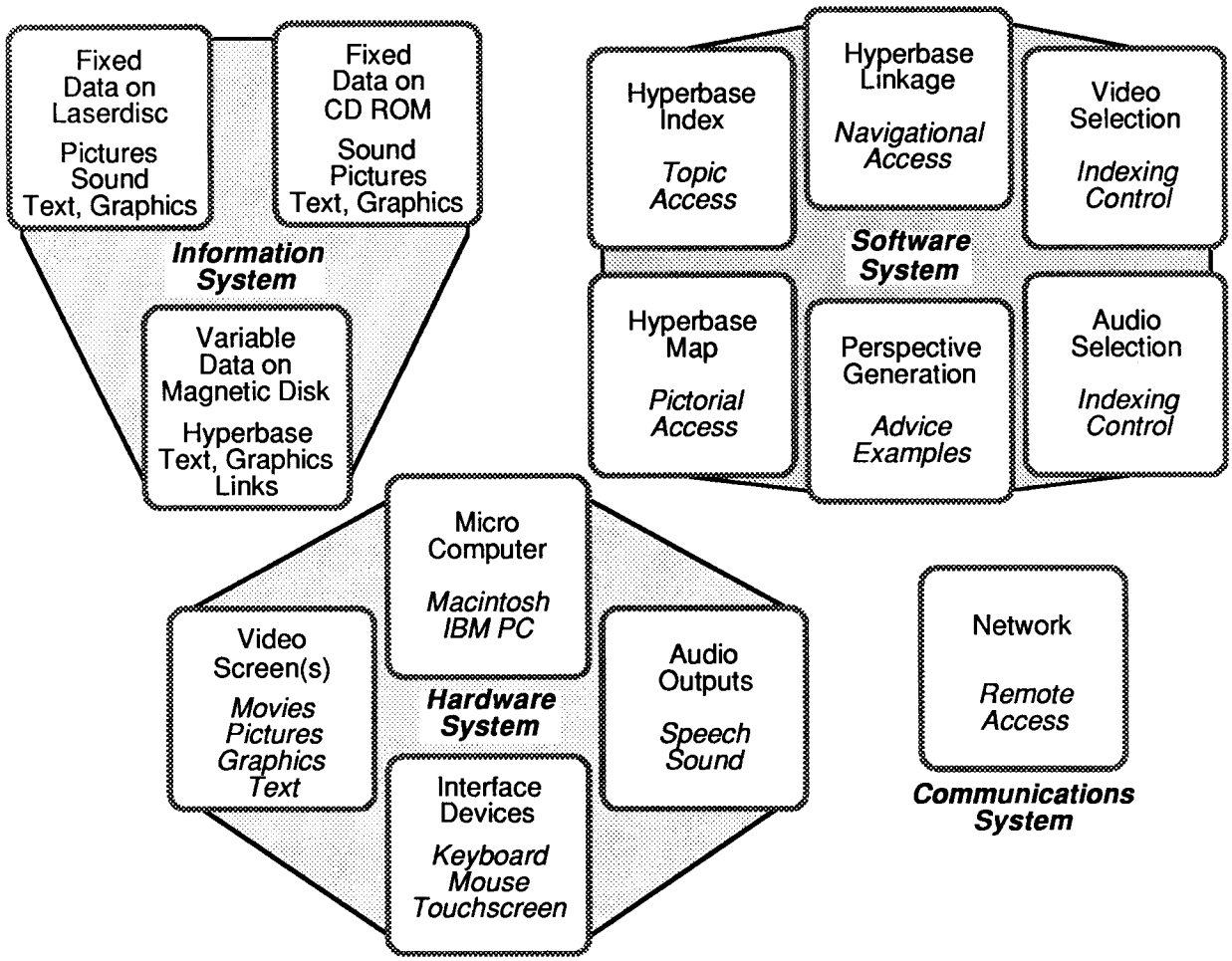



**Figure 1. Hypermedia system architecture**

In the 1980s, advances in technology made hypermedia systems feasible, and they are attracting widespread interest for a variety of applications (Young, 1986; Gassée, 1987). However, the essential features of hypermedia systems are not well defined, and there is a danger that systems will not fulfil expectations and that the term will become over-used and lose its meaning. A combination of microcomputer, laserdisc, CD ROM and graphic and aural input-output devices as shown in Figure 1 may provide an adequate technical foundation for hypermedia system development, but it does not in itself constitute an effective hypermedia system. Most of the problems now lie in the software for information storage, and manipulation and

retrieval, particularly in the human-computer interface; the most frequent criticism of hypermedia implementations is that they are too complex and users get lost among the information and facilities (Conklin, 1986).

The massive success of Bill Atkinson's implementation of HyperCard on the Macintosh is an indication that effective software for hypermedia systems can be developed. It has enabled a new constituency of computer system developers to emerge, able to produce high-quality information systems with little training or experience in programming. The hypermedia concept has been significant in capturing the computer-supported, open-ended access to a diversity of media; media that offers so many attractive possibilities for creative thinking, problem-solving and networking by individuals and dispersed groups. It provides a basis for the integration of the very wide variety of resources offered by information technology within a coherent but non-restrictive framework. Data-processing, simulation, information retrieval, text processing, presentation graphics, databases, knowledge bases, expert systems, knowledge acquisition, and so on, may all be regarded in a significant sense as particular aspects of hypermedia systems.

The concept of hypermedia is very open-ended, and a range of systems are being developed for a diversity of applications (Gaines & Vickers, 1988; Barrett, 1989), from simple hypertext systems such as Learning Tool (Kozma & Roekel, 1986) and Guide (Owl, 1986), to electronic books (Weyer, 1982) and encyclopedias (Weyer & Borning, 1985), through programmable hypergraphic systems such as NoteCards (Halasz, Moran & Trigg, 1987), from complex, multi-media systems for literary studies (Yankelovich, Landow & Cody, 1987) to knowledge-based, multi-media systems for expert system development (Neuron, 1986), and sports coaching (Vickers & Gaines, 1988). However, the essential openness and generality of hypermedia should not lead to vagueness in the concept or system design. In our developments of knowledge-based hypermedia systems, we have found it necessary to develop a vocabulary to describe and design various features of these systems, and have also been involved in extensive discussions as to what constitute the essential features of hypermedia. Many general questions have also arisen: What essential role does information technology play in hypermedia? What differentiates hypermedia from conventional information technology? What differentiates hypermedia from conventional media?

## HYPERTEXT AND HYPERMEDIA FUNCTIONALITY

Within hypermedia technology, some important distinctions are worth making: between the hypermedium as a general carrier of information; a form of system using that hypermedium; a particular instance of such a system; and the the material that particular system carries. We use the terms hypermedium shell, or *hypershell*, for a general system capable of carrying material in a particular hypermedium; hypermedium system, or *hypersystem*, for a particular instance of such a system loaded with material; and hypermedium base, or *hyperbase*, for the totality of material carried by a particular system. These neologisms are

necessary to describe precisely the structure and contents of hypermedia systems, and are coined on a model of *expert system shell, data base, knowledge base*, and so on, so as to link with past referents. They remind us of the novelty and generality of the hypermedia concept, which subsumes many aspects of previous media and information technology, but goes beyond them in essentially new features that cannot be subsumed by past concepts.

Two other important concepts in hypermedia are the linkage structure embedded in the material and the paths through the material generated by a user following parts of the linkage structure. We use the term *gateway* for a link within material to other material, and the term *perspective* for the viewpoint into the material that is built up through access to it. These have obvious spatial analogs and correspond to important features of hypermedia; that linkages are embedded in the material, and that users build up new viewpoints to the material through their modes of access to it.

As media, hypermedia systems are best defined by their *functionality*, the capabilities that they offer. It is useful to distinguish those aspects of functionality that are *essential*, in that systems without them would not be regarded as hypermedia; *expected*, in that systems without them would be regarded as limited examples of hypermedia; and *desirable*, in that systems with them would be regarded as particularly good examples of hypermedia. The following sections outline reasonable requirements for hypermedia functionality.

## ESSENTIAL FUNCTIONALITY

The essential features of hypermedia come from the intention of bringing people into effective communication with sources of knowledge through access to the hyperbase that is as direct as possible.

### *Integration*

An essential feature of a hypermedium is that the medium itself carries gateways linking materials in the medium. Standard media require external indexes or directories to carry such linkage information. In books, footnotes, sidenotes, literature citations and explicit references may be used to approximate such gateways.

### *Freedom*

An essential feature of a hypermedium is the freedom to browse through the material along paths which are not predetermined, or determined by the system in response to user answers to its questions. A hypermedium is as mode-free as possible within a particular context and across contexts. Note that this freedom may sometimes conflict with usability, but this should be overcome through guidance not restriction.

### *Flexibility*

An essential feature of a hypermedium is its flexibility in giving multiple perspectives upon the same data and in allowing perspectives to be established which were not built in to the original hyperbase. New perspectives will often be generated as the side-effect of action such as search activity. There is an analogy to the way in which a traveller may come upon a significant but unexpected viewpoint by virtue of his attempt to get from one place to another rather than by specifically intending to find, or mentally create, that viewpoint, as might a skilled artist.

### *Usability*

An essential feature of a hypermedium is that the functionality provided is made as usable as possible. The functionality/usability distinction is a critical one in the human factors of computing. Ease of access to media has always been important, and the incorporation of information technology should simplify access, not make it more complex.

## EXPECTED FUNCTIONALITY

The expected features of hypermedia are logical extensions of the intentions, and experience, of bringing people into effective communication with sources of knowledge.

### *Diversity*

An expected feature of a hypermedium is its integration of diverse audio and visual media. Hypertext and hypergraphic systems without audio or laserdisc capabilities can be examples of hypermedia, but many of the important design problems do not manifest until a diversity of media are considered.

### *Extensibility*

An expected feature of a hypermedium is its extensibility in allowing new material and new perspectives to be added to the hyperbase. Some components of current hypermedia systems, such as laserdiscs, are not extensible at this stage of the technology. This is a significant limitation to their role in hypermedia, and to the utility of particular hypermedium systems. A major design objective for a hypermedium system is to overcome this limitation, in the short term by providing remedial extensibility through the storage media of the computer, and in the long term by developing extensibility in components such as laserdiscs.

### *Sociality*

An expected feature of a hypermedium is its sociality in allowing multiple users to access and update a hyperbase (Greif, 1988). Nelson, in particular, has emphasized the communicative, social role of hypermedia (Nelson, 1980). The designers have noted that, "One of the biggest limitations of NoteCards is

the lack of support for collaborative work" (Halasz, Moran & Trigg, 1987), and have suggested extensions to remedy this (Trigg, Suchman & Halasz, 1986).

### *Spatiality*

Existing hypermedia may be seen as making strong use of a spatial metaphor. Information is laid out in space, and linkages are seen as paths accessed through gateways. This is so natural that it may not be seen as a metaphor; knowledge in general has no intrinsic spatial representation, but we are so used to its presentation in books and through diagrams that we are conditioned to think of much knowledge in spatial terms. Other metaphors are possible and commonly used in our language, such as time and force (Lakoff and Johnson, 1980), but the spatial metaphor plays a central role in existing hypermedia.

## DESIRABLE FUNCTIONALITY

The desirable features of hypermedia stem from the opportunities offered by hypermedia to subsume, and give, effective end-user access to many information technologies.

### *Programmability*

A hypermedium shell provides an extraordinarily powerful end-user interface to a computing system, providing for intelligent help and presentation facilities in any depth required. To make use of this potential, the shell must provide programming hooks into other programmed systems for data processing, simulation, databases, and so on. A major limitation of simple hypergraphic systems is that they are not programmable in this way. *NoteCards* provides programming capabilities, but only within the Lisp environment. The *HyperTalk* programming language is probably the most important feature of *HyperCard.*

### *Orientability*

One of the defects of current hypergraphic systems is that it is easy for the user to become disorientated, losing track of where he is in the hyperbase, how he has arrived there, and what further territory is open to exploration (Conklin, 1986). It is desirable that some form of overview facilities be provided to map the hyperbase and show the user's path through it.

### *Guidability*

It has already been noted that the requirement for *freedom* may conflict with that for *usability*. A mode-free system that makes every possible choice available to a user may be difficult to use because it places an excessive decision-making burden on the user. The hypersystem should make provision for a range of different forms of guidance which do not restrict choice, but indicate the basis of choice, the most likely choices, and the reasons for these.

### *Recreatability*

To optimize their perspectives, users may take advantage of the freedom to browse through the system looking for relevant data. However, it is possible that they will regard the finishing perspective as less desirable than some earlier one, and it is important that they can checkpoint a perspective at any time and recreate it easily.

### *Attributability*

A hyperbase contains a diversity of information of various origins, dates, and reliability. It is desirable that a user be able to check the attribution of material. Technically, this can be just another gateway, but it requires proper management of accessions to the hyperbase.

### *Communicability*

It is never clear to either the user or the system whether material presented has been understood. At times this can be very important, and it is desirable that explicit gateways are established to material which checks the understanding of other material.

## FUTURE DIRECTIONS

Hypermedia is a hot topic, and there are many major initiatives in place internationally. I will highlight three of particular importance.

### *Standardization*

The value of a medium is critically dependent on the accessibility of material in that medium. We have come to take for granted the ease of access to literature in printed books and journals. We have achieved a remarkably high degree of accessibility to textual material on electronic networks. Hypermedia has the potential to increase the quality and utility of knowledge communication through both on-line and off-line electronic media. However, accessibility is a major problem that needs to be addressed if the full potential of the new medium is to be realized. Hypermedia will be little more than a curiosity if material is accessible only to those with a particular hardware/software environment closely related to that of the originator.

Thus, standardization issues are relevant to hypermedia at what may appear to be at an inappropriately early stage in its development. Any proposed standards must take into account the volatility not only of the technology, but also of the underlying conceptual framework. What is needed are achievable principles of standardization that encourage innovation rather than stifle it; for example, in allowing a novel hyperbase to be issued in such a way that it demonstrates its full capabilities in the intended hypershell, but also functions usefully in more conventional hypershells. There are significant examples of the achievement of

such graceful degradation in existing media, such as the mono decoding of stereo phonograph records and the dual transmission of low-resolution (PICT) and high-resolution (Postscript) images in the same document. It is appropriate at this stage of development of hypermedia to establish a *standards architecture* that supports and encourages such stratified information encoding.

The first conference on standards for hypertext and hypermedia took place in Washington in January 1990 under NIST sponsorship (Moline, Benigni, Baronas, 1990). A second is already scheduled for August 1990. We can expect to see increasing emphasis on standards issues as significant applications of the technology develop.

### *Improvements in the Base Technology*

The commercial impetus behind hypermedia technology is leading to a dramatic pace of technological change, product innovation and improvement, and price reduction. As with most computer technology, the moral is "buy only what you need now, and use it heavily, because it will be obsolete before you get it!"

Apple Corporation has been the leader in hypermedia innovation, and at its Developers Conference in May 1990, six products were unveiled that are pointers to future developments:

- A number of new video cards that can show high-quality laserdisc images in Macintosh windows, scaling them to size and superimposing Macintosh text and graphics. An outstanding example was a product from Videologic capable of displaying two such windows and costing some $2500 U.S.
- A number of new sound digitizers and compression systems capable of capturing and replaying multiple tracks of CD-quality sound.
- Apple's ISDN card that couples the Macintosh into integrated services, digital networks now become significant multimedia public services in countries such as France and Japan.
- Apple's System 7 operating system that supports integrated multimedia integration both within the workstation and across networks. Any application can "publish" material to which other applications can "subscribe." This will be supported by a wide range of updated versions of current applications such *HyperCard*, *Excel*, *Word*, *Director*, and so on. The major impact on hypermedia will be that it will be possible to create multimedia systems with any required functionality by simple scripts "glueing" these different, commercially supported applications together.
- Apple's *HyperCard 2* hypermedia programming system with greatly improved speed and functionality, but retaining *HyperCard*'s essential simplicity and open architecture. The major impact on hypermedia will be that *HyperCard 2* offers exceptional ease of integration with other applications. Macintosh programs can now incorporate *HyperCard*'s functionality as if it were their own, thus gaining a powerful programming language, flexible user interfaces, and laserdisc control with little additional programming.
- Macrominds's *Director 2* multimedia programming system facilitating the development of complex multimedia productions.

As emphasized in the introduction, the improvements to the naturalness and ease of programming are most important to the future of hypermedia. This is being addressed as a high-priority enterprise by major

companies. At what point these efforts will be sufficient to tilt the balance to the non-specialist control of the new medium is not yet clear, but there is progress in the right direction.

### *Semantic Networks*

The linkage and control structures underlying hypermedia are not just computer data structures - they represent human knowledge in its most creative form, in the association and relationship of ideas. Currently, there is little computer support of this representation - knowledge is behind the structures imposed on anarchy by the hypermedia producer, and knowledge is reconstructed from this by the hypermedia user. However, in the 1980's there have been developments in artificial intelligence and knowledge-based systems research that do support knowledge representation in the computer, and these may be expected to play an increasingly important role in hypermedia systems.

In particular the series of knowledge representation schemes and tools commencing with *KL-ONE* (Brachman & Schmolze, 1985), developing through *KRYPTON* (Brachman, Gilbert & Levesque, 1985) and currently culminating in systems such as *CLASSIC* (Borgida, Brachman, McGuinness & Resnick, 1989) and *LOOM* (MacGregor, 1988) have reached a maturity of technology which offers the promise of knowledge representation 'utilities' or 'services' in Levesque's (1984) terminology. It is now feasible to develop knowledge representation servers on par with floating-point arithmetic units and numeric libraries, as software modules with well-defined functionality and fast, reliable performance. As with arithmetic units, such servers by no means solve all the problems of a particular application domain, but they do greatly reduce the burden of system development, allowing effort to be focused on the specifics of particular systems rather than on what should be general utilities.

These modern semantic networks, embedded in fast servers with strong logical foundations, offer important support to the linkage structures of hypermedia. They are an equivalent advance to the original development of programming languages in the 1950s, the high-level languages of knowledge representation.

## CONCLUSIONS

Hypermedia may be seen as a very significant stage in the evolution of media in general, and in that of information technology as a medium for human knowledge in particular. The hypermedia concept provides a basis for the integration of the very wide variety of resources offered by information technology within a coherent but non-restrictive framework. In particular, the combination of computer and laserdisc technologies possible with hypermedia greatly enhances the applications of both these highly significant information technologies.

The most important directions of development for hypermedia are those which improve the naturalness and ease of programming, reducing dependence on computer specialists, and putting control of the medium in the hands of creative producers. Essential, expected, and desirable functionality for hypermedia systems have been defined and discussed in these terms.

Standards for hypermedia need to take into account the diversity of content and delivery systems of hypermedia, focus on a standards architecture that cross-references existing and developing standards in the content areas, and specifies the linkage structures peculiar to hypermedia in a well-defined and generally applicable form.

The base technology is rapidly improving in functionality and decreasing in cost; hypermedia is an immature new medium at the start of its learning curve. Rapid and accelerating change can be expected.

Progress in knowledge representation in artificial intelligence has reached a stage where widely applicable techniques are becoming available. These will be highly supportive of the knowledge structures underlying hypermedia.

## ACKNOWLEDGEMENTS

Financial assistance for this work has been made available by the Natural Sciences and Engineering Research Council of Canada. I am grateful to my colleagues Larry Katz and Joan Vickers for many discussions, and for access to their research which has influenced this paper.

Moline, J., Benigni, D. & Baronas, J. (Eds.). (1990, January). Proceedings of Hypertext Standardization Workshop. Washington: NIST Special Publication, 500-178.

Nelson, T. (1980, November). Interactive systems and the design of virtuality. Creative Computing, 6(11), 56-62.

Neuron (1986). Reference Manuals for aiScreen and aiVision. Palo Alto, California: Neuron Data.

Trigg, R., Suchman, L. & Halasz, F. (1986, December). Supporting collaboration in NoteCards. Proceedings of Conference on Computer Supported Cooperative Work. Austin, Texas: MCC.

Vickers, J. N. & Gaines, B. R. (1988, March). A comparison of books and hypermedia for knowledge-based sports coaching. Microcomputers for Information Management, 5(1), 29-44.

Weyer, S. (1982, July). The design of a dynamic book for information search. International Journal of man-Machine Studies, 17(1), 87-107.

Weyer, S. A. & Borning, A. H. (1985, January). A prototype electronic encyclopedia. ACM Transactions on Office Information Systems, 3(1), 63-88.

Yankelovich, N., Landow, G. & Heywood, P. (1987). Designing hypermedia "ideabases" – the intermedia experience. IRIS Technical Report, 87-4. Providence, Rhode Island: Brown University.

Yankelovich, N., Landow, G. P. & Cody, D. (1987). Creating hypermedia materials for English literature students. SIGCUE Outlook, 20, 1-11.

Young, J. S. (1986, March). Hypermedia. MacWorld, 3(3), 116-121.