TRANSFORMING TEXT INTO HYPERTEXT FOR A COMPACT DISC ENCYCLOPEDIA

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ABSTRACT
A hypertext version of a multi-volume engineering encyclopedia on a compact disc is described. The methods for characterizing the explicit and implicit structure of the document, the novel user interface to the compact disc version, and the design and development lessons that apply to any hypertext project involving realistic amounts of text and graphics are discussed.

KEYWORDS: Browsing, CD-ROM, compact disc, documents, encyclopedia, hypermedia, hypertext, searching, text.

INTRODUCTION
The Engineering Data Compendium [3] is a highly specialized encyclopedia containing comprehensive reference data about human perception and performance. Its four volumes include nearly 3000 pages of text and more than 2000 figures, tables, and illustrations. The Compendium's primary users are designers of aircraft cockpits, control rooms, or other systems with complex user interfaces.

Recently, I led a team that designed and built a compact disc version of the Compendium. A user-oriented and document-oriented methodology was implied by our objectives:

1) Build upon the experience people have with printed reference books;

2) Preserve and enhance the extensive organization and user aids explicitly designed into the printed version;

3) Make use of the structure implicit in the printed version that is not fully exploited because of constraints in the printed form or the process by which it was developed; and

4) Devise additional features to enhance the accessibility and usability of the information in the Compendium.

This approach contrasts with the technology-driven approach seen in many other compact disc document collections, which have apparently been transformed from their printed forms by mechanical application of full-text indexing. Not surprisingly, the Compendium's user interface also differs significantly from that provided on most compact discs. Most discs rely on Boolean search of the full text as the primary method of finding information [4], despite ample evidence that people find such interfaces hard to use [16]. In contrast, our user interface exploits the Table of Contents, the "back-of-the-book" Index, and other parts of books with which users are highly familiar.

This project was not a "proof of concept" or prototype demonstration with a small, ad hoc document database. It was a full-scale research and development effort to transform a multi-volume reference book into compact disc form while exploring new concepts in information storage and information retrieval. We made extensive use of "hypertext", defined by Conklin [5] as computer support for links within and between documents. Hypertext is not a new concept, but it has recently been popularized by new software tools for user interface design such as Apple's HyperCard(Tm) and OWL's Guide(Tm).

Creating a hypertext encyclopedia with realistic amounts of text and graphics is an engineering problem that requires disciplined methods for characterizing the physical and logical structure of the document, identifying the constraints embedded in this structure and in the target environment, and making the required trade-offs. We are far from a systematic view of "hypertext engineering," but the lessons we learned from this project are a start [8].

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1.103 Range of Light Intensities Confronting the Eye

The human eye is sensitive to a wide range of light intensities, from a minimum visible level of about 0.000003 lux to over 300,000 lux. Vision at very low light intensities is mediated by the rods in the human retina, and by the rod vision is poor with regard to color (hue). Vision at high intensity levels, e.g., daylight, is known asphotopic vision and is mediated by the cones, photopic vision is characterized by high visual acuity and the perception of color. Mesopic (intermediate) vision (mediated by both rods and cones) occurs at intermediate light intensities (e.g., moonlight).

Cross References
1.10 Range of visible energy in the electromagnetic radiation spectrum

Key Terms
Illuminance level; luminance; mesopic vision; photopic vision; scotopic vision; visual acuity; visual field; mesopic visual acuity

Key References

Figure 1. The range of light intensities that confront the human eye. (Adapted from C. H. Doee. L. & Clark, J. C. (1940). Designing for the eye. National Engineering Review, 1, 5-9. Reprinted with permission.)

THE ENGINEERING DATA COMPENDIUM

The Engineering Data Compendium is a multi-volume engineering encyclopedia whose 1138 entries contain comprehensive data on human perception and performance. In printed form, the Compendium is organized in three primary volumes that contain the entries. A fourth volume, the User's Guide, contains a Table of Contents, Index, Glossary, and other aids for finding relevant entries.

Figure 1 above shows a typical Compendium entry (reduced from two facing pages).

The Compendium is the latest product of a long-term research and development program aimed at making human perception and performance data more accessible and useful to designers with little knowledge or experience in the subject areas. The core information in the Compendium comes from the highly-regarded Handbook of Perception and Human Performance [2], transformed from a researcher's perspective to a practitioner's perspective.

This transformation required detailed study of how designers use human performance data [1][9], and this task analysis led to a novel format for presenting technical information that makes the Compendium highly usable in printed form [10]. This format also makes the Compendium an excellent candidate for hypertext representation on a compact disc. The format includes:

* Information segmented into small, self-contained entries that deal with narrow, well-defined topics. In the printed version, entries typically appear as a single spread of two 8.5 x 11 inch facing pages.

* Entries arranged according to a hierarchical table of contents in twelve broad topic areas and in several dozen sections and sub-sections. Each entry has ten explicit cross-references to other entries and dozens of implicit cross-references based on shared key words and glossary terms.

Figure 2 shows how the brightness of a star patch changes with the angular elevation of the sun above the horizon.

Figure 3 shows the brightness in a mesopic vision range. The sun patch changes with the angular elevation of the sun above the horizon.

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The user interface design emerged from our experiences as graphics requiring another 150Mb. In addition, the disc of the text and graphics from the printed version. The text of the Compendium occupies about 20Mb, with the graphics requiring another 150Mb. In addition, the disc contains another 40Mb for various indexes.

The user interface design emerged from our experiences as users of reference books, from interviews with users of the printed Compendium, from field studies of how designers use information, and from a review of other systems. The user interface supports a wide variety of methods for finding relevant Compendium entries. These methods include browsing of the Table of Contents, Index, and other hierarchical user access points, searching using Boolean expressions, and following links among related entries.

Hierarchical Browsing
The user interface emphasizes hierarchical browsing of the Table of Contents, Index, and other hierarchical user aids as a means for finding relevant Compendium entries. This is not "browsing" in the sense of casual, undirected, serendipitous information-seeking activity that is often contrasted with Boolean search [11]. We define hierarchical browsing as exploration by the progressive display of detail, and it is especially appropriate and effective for richly structured access points like the Table of Contents. Hierarchical browsing allows the user to exploit the extensive organization of the Compendium in locating information, in contrast to Boolean search of the full text, which ignores this structure.

The browser was designed after studying several other browsers to discover the range of functions they provide. Following the study, we identified seven distinct functions in ThinkTank(Tm), Document Examiner(Tm) [17], NaviText SAM(TM) [13], Guide(TM), and KnowledgeSet(TM). These browsers differ remarkably in how they provide these functions (e.g., representing "where you are" and how details are expanded or hidden). More exploration of the design space and careful observation of the usability of different browsers is needed.

In the browser, the initial display of the Table of Contents contains only the 12 major topic areas into which the 1138 entries are arranged. Selecting an item expands it to show the levels below it in the hierarchy. At the same time, the details in other parts of the hierarchy are hidden from view. This "fisheye" view helps to focus the user's attention on the most recently selected item [7]. When the selected item is an entry number, the entry is displayed on the screen.

The printed Index contains over 2000 top-level headings and 10,000 items in all. An alphabetic level (i.e., the letters A to Z) was added to make it easier for the user to locate a starting point in the Index hierarchy. Because the Compendium contains many engineering and scientific terms with many distinct senses, it can be more efficient and precise to browse the Index than to search the full-text. This design guideline should hold until computer-generated indexes are as good as the ones created by human indexers.

Searching
The user interface supports Boolean search of the full text of the Compendium, and each of the ten text parts of each entry is treated as a separately-indexed field. But, our task analysis led us to use fields in a subtly different manner than most search interfaces. First, we define as the default search scope the Title, Key Terms, General Description, Application, and Captions fields of the entries. This increases precision by limiting searches to those fields that are most likely to contain the information needed by designers. Users can change the set of fields for other search tasks; for example, limiting the search to the Methods field may be appropriate for a researcher looking for uses of a particular experimental technique.

Second, the user receives the results of a search as a list of the matching entries, not as a list of matching fields. Users are more interested in knowing how many entries match the query than in knowing how many fields match. Selecting an entry from the results list displays it on the screen.

Finally, when viewing one of the entries found by a search, the user can select the "Next Hit" or "Previous Hit" from the list of candidate entries. This function was modeled after the familiar process of sticking your thumb in the Index at the back of the book to hold your place while you go back and forth to view each entry.

Viewing Entries
When an entry is selected, it is displayed in a "viewer window" that occupies most of the display screen. The text and graphic portions of each entry are displayed separately, and the user must alternate among them. This aspect of the user interface design was largely dictated by the computing environment most available to our intended users, the industry-standard PC or AT-class microcomputer with a standard 13-inch diagonal display screen.

Several alternative designs were experimented with and rejected for displaying text and graphics. Side-by-side text and graphics windows and a single window in which
graphics were embedded in the text led to graphics that were difficult to read because they were too small. Resizable text and graphics windows made sense in principle, but many of the figures and tables contained multiple panels or spanned more than one page, so making them smaller made little sense. A better solution was to break up the complex graphics into parts. This approach made it possible to make the graphics larger and more legible on the small screen. Still, the resolution of the graphics is limited to 80 pixels per inch on the typical 640x400 pixel monitor, which suffers in comparison to the 300 bits per inch resolution offered by the printed page.

Figure 2 below shows how the screen appears when the text portion of the Compendium entry shown in Figure 1 is displayed in the viewer window. This figure also shows several of the important features of the user interface. Features whose role may not be obvious include:

The Main Menu. The main menu always appears at the top of the screen to show functions that are always available. On a larger screen, these functions might be arranged in dedicated windows. Novel functions invoked from this menu include bookmarks for returning to previously viewed or marked entries, and a facility for making notes on an entry or other part of the Compendium.

The Context Line. The context line describes the user's current context, and is the line just below the menu at the top of the screen. In Figure 2 the context is the title of the entry being viewed.

The Help Line. The help line is the third line, below the Context Line, which contains a brief context-sensitive help message. More detailed context-sensitive help appears if the user selects HELP from the main menu.

Sidebar (here labeled Entry Viewer) and Bottom Panel. These are context-sensitive areas that present various "function buttons" and information areas. Here the Sidebar supports several hypertext functions to display the figures or other graphics associated with the entry or other related entries. The Bottom Panel contains functions that enable the user to locate and "jump" to words that occur in the text displayed in the browser or in the entry viewer.

Hypertext Functions
The top button, labeled "Figure", displays a menu of the figures, tables, and illustrations contained in the entry being viewed. Selecting one of the items from the menu displays it in the viewer window, as shown above in Figure 3.

In Figure 2, the three buttons below "Figure" in the sidebar invoke links to other Compendium entries to display them in the viewer window. "Entry#" displays any entry specified by number, while "Next" and "Previous" display entries that follow or precede the current entry in the Table of Contents order.

The remaining four sidebar buttons are enabled when their functions are contextually appropriate. "Browser" is enabled if the entry was selected by browsing the Table of Contents, Index, or other hierarchical access point; selecting it returns to that context. The "Browser" function was designed by analogy to "Hits", which returns the user...
to the list of candidate entries located by a Boolean search. "Previous Hit" and "Next Hit" are shortcut methods of selecting from the most recent candidate list.

Besides the hypertext functions that are invoked by explicit sidebar "buttons", several other navigation and information retrieval functions are supported. An entry can be displayed by selecting it from the list of Cross References. Users can also follow the implicit links between entries based on shared Key Terms. Selecting a key term displays a list of entries that share the term, and choosing one of them displays it in the viewer window. Another set of links are between the first occurrence of a Glossary term in the text and its definition. Selecting a highlighted term "pops up" a window that contains the definition.

TRANSFORMING TEXT INTO HYPERTEXT

It may appear that the Compendium is inherently well suited for hypertext. The core notions of hypertext are that modular text entities are linked together, and to make it easy to follow the links, the text and links are supported on a computer. Similarly, the essence of an encyclopedia is that it is a collection of text units that are designed to stand alone as separate modules but which are enhanced by cross-references to other entries. Nevertheless, though the task of translating encyclopedia text into hypertext seems simple, it defies a straightforward solution. The basic problem with the simplistic model of going from text to hypertext is that it can be difficult to identify the text units and link structure, even for an encyclopedia.

Identifying the Text Units

The Compendium entries have unique titles, which makes it natural to design the hypertext version with them as the basic text units. A good design rule might be to choose as the basic text unit the smallest logical structure with a unique name. The unique names are easy to refer to and manipulate in the user interface. Entries serve as the "selection key" in the hierarchical browser, in candidate lists as the result of a search, as "bookmarks" of previously viewed information, and as embedded cross references.

In contrast, physical structures of documents like pages or paragraphs are less suited as hypertext units because they have less relevance for the user and are hard to attach a "handle" to in the user interface.

Identifying the Links

It is more challenging to build the links between related information in a hypertext document. The hypertext designer must understand both the explicit and implicit link structure in the printed version. Each of the 1100 Compendium entries has about 10 explicit cross-references to other entries, and dozens more implicit ones based on shared key terms and glossary items. Thus it might have been possible to create hundreds of thousands of links on our disc. We had to decide which links to create, and which ones to not create. We chose to limit the number of links unless we were sure that they were "good" ones. Most of the possible links are not good ones.

The hype of hypertext in the popular computing press is that links are powerful and exciting -- the user can sail in a sea of text units, following links between items that are related in some interesting way. The user might start reading about Buffalo, New York and end up finding out about the design for the Buffalo nickel. For designers using a reference book to answer design questions, however, this model of hypertext is misguided. The challenge for hypertext designers is to understand the user's task, and to support links that follow from some model of the user's need for information in some particular context. Unless the user's task is to wander and explore the document, it is essential NOT to link pieces of information that are related in idiosyncratic or superficial ways. Unconstrained hypertext linking leads to spaghetti documents that like spaghetti code contain too many gotos. Instead of creating a "spaghetti document" with the resulting disorientation problems that others have noted [5] [6], it seems more sensible to prevent the disorientation caused by unconstrained linking. Without careful analysis of how users make use of the hypertext structures already explicit in and implied by the printed Compendium, it is premature to add new ones.

LESSONS LEARNED: TOWARD "HYPERTEXT ENGINEERING"

The Engineering Data Compendium was inherently an excellent document to transform to hypertext because of its modular structure and numerous links. Nevertheless, months of work was required to develop a complete understanding of the Compendium and to analyze the tasks for which it is used. A project of this scale is impossible without a comprehensive understanding of the document and its users. We were fortunate to have one of the editors of the Compendium as the project sponsor and the other as a member of the design team.

We have conveyed some of the lessons learned about how to identify and exploit the structure of a document in transforming it to hypertext. We know the value of these insights because they did not come cheaply. From conception to completion this project cost about $250,000, and the portion attributed to design and analysis is much larger than that due to text and graphics processing. Given the costs of a real project with realistic amounts of information, it is not surprising that the published literature on hypertext contains little work directly relevant to the scale or scope of the problems we faced in our project. (Most of the hypertext literature deals with creating small hypertext documents, not converting large documents to hypertext). We found useful lessons in the Document Examiner [17], Navitext [13], Oxford English Dictionary [14], and Superbook [15] projects. Oren's paper describing
lessons learned from the *Grolier’s Electronic Encyclopedia* project was also helpful [12].

Hypertext is an attractive concept and coupled with the enormous storage capacity of compact discs it opens up exciting new possibilities for information storage and retrieval. To make it more than a buzz word involved a mixture of research, engineering, and tedious "grunt work" that we had not anticipated, but which we now believe characterizes any hypertext project of realistic scale.

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Mike Adams from Iopis Corporation of Columbus, Ohio managed the premastering of the text and graphics. He also managed the user interface implementation work done by Jack Johnson, Steve Keller, and Leonard Rivers.

REFERENCES


TextTiling is a technique for subdividing texts into multi-paragraph units that represent passages, or subtopics. The discourse cues for identifying major subtopic shifts are patterns of lexical co-occurrence and distribution. The algorithm is fully implemented and is shown to produce segmentation that corresponds well to human judgments of the subtopic boundaries of 12 texts. A structure based on the notion of subtopic shift, and an algorithm for subdividing expository texts into multi-paragraph "passages" or subtopic segments. In this work, the structure of an expository text is characterized as a sequence of subtopical discussions that occur in the context of one or more main topic discussions. User Interface Design for the HyperTies Electronic Encyclopedia, Hypertext â€™87 Proceedings, November 1987. [Smith & Weiss, 1988]. Smith, John & Weiss, Stephen. Glushko, Robert J. Transforming Text Into Hypertext For a Compact Disc Encyclopedia, Proceedings of CHI â€™89, ACM Press, 1989. [Halasz, 1988]. Halasz, Frank. Compact Disc Background: Ever since the invention of the phonograph in 1876, music has been a popular source of home entertainment. In recent years, the compact disc has become the playback medium of choice for recorded music. â€“ Rashid Riaz. Cite this article Pick a style below, and copy the text for your bibliography. MLA. Chicago. The impulses are then transformed into waves for playback through stereo speakers. CD-ROMs. CD-ROMs (and audio CDs) contain information that cannot be erased or added to once the discs have been created.