XLibris: The Active Reading Machine

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ABSTRACT

Active reading [1] is the combination of reading with critical thinking and learning, and involves not just reading *per se*, but also underlining, highlighting and commenting. We have built the XLibris "Active Reading Machine" to explore the premise that computation can enhance the active reading process. XLibris uses a high-resolution pen tablet display along with a paper-like user interface to emulate the physical experience of reading a document on paper: the reader can hold a scanned image of a page in his lap and mark on it with digital ink. XLibris monitors free-form ink annotations made while reading, and uses these to organize and to search for information. Readers can review, sort and filter clippings of their annotated text in a "Reader's Notebook." Finally, XLibris searches for material related to the annotated text, and displays links unobtrusively in the margin. XLibris demonstrates that computers can help active readers organize and find information while retaining many of the advantages of reading on paper.

Keywords

Paper-like user interface, reading online, affordances of paper, pen computing, dynamic hypertext, document metaphor, information retrieval

INTRODUCTION

Active reading is the combination of reading with critical thinking and learning, and is a fundamental part of education and knowledge work. Active reading involves not just reading *per se*, but also underlining, highlighting and scribbling, either on the text or in a separate notebook [1]. Readers often use these marks later for review and retrieval. In addition, active reading often requires readers to move from one text to another to satisfy their information needs.

The XLibris system was designed to combine the advantages of paper-based reading, annotating and note taking with the power and flexibility of a computer [3]. It

uses a paper document metaphor to support document reading and annotation tasks. The user interface consists of three main features: a document viewer, the Reader's Notebook and margin links.

SYSTEM ARCHITECTURE

XLibris runs on a Mutoh 12.1" (30.7 cm) diagonal 1024x768-pixel tablet display tethered to a PC. The display is used in portrait orientation (rather than the landscape orientation of typical laptop displays) because that aspect ratio is better suited to the display of documents. XLibris displays documents as 100 dpi color bitmap images shrunk slightly to fit the aspect ratio and size of the display; the margins are clipped slightly on each side.

Our software runs on Windows 95/NT, and uses the Win32 API. OS dependencies are encapsulated in a separate library to maintain portability. XLibris implements all rendering and rotates the display to portrait mode. Documents scanned or "printed" into XLibris are stored in an "image + text" file format. The image of each page is stored together with a thumbnail. The text, inferred from print commands or from OCR, is tied to the image by a bounding box for each word.

PAPER DOCUMENT METAPHOR

XLibris uses the paper document metaphor to capture several important characteristics of paper documents. The metaphor includes a display that emulates the appearance of a sheet of paper, an interface for viewing pages in the linear order of the document, the ability to mark in any place on any page, and cues about the size of a document and about the reader's location within it.

XLibris emulates the physical experience of reading a document on paper. Readers hold a lightweight pen tablet that displays one page of a scanned or printed document at a time. As on paper, readers can mark anywhere on the page with colored pens, highlighters, and an eraser.

XLibris provides a variety of methods for navigation. Readers can thumb on pressure sensors on the case to move to the following or preceding page [2]. Alternatively, a "document view" showing thumbnails of all pages simultaneously can be used to select the desired page, or the Reader's Notebook view described below can be used to find a page with a familiar annotation. A view history allows user to backtrack through the reading session in time.

XLibris also provides a "workspace view" to help readers navigate between documents. The workspace view displays a thumbnail (with a shadow that indicates document size) for each of the reader's documents. Each thumbnail is linked to the front page of the corresponding document. Although almost entirely illegible, the thumbnails retain the layout information and also include any annotations.

Commands for switching views or selecting pens are invoked from unobtrusive menus that do not interfere with reading or annotating. A static "button bar" at the bottom of the display emulates "silk screen" buttons on the case. And a pie menu pops up when users press down with the pen and hold it in one place or when users press a button on the pen barrel.

READER'S NOTEBOOK
The Reader's Notebook (Figure 1) is a notebook of clippings derived from readers' annotations. The Reader's Notebook supports review and retrieval much like a paper notebook, but does not require readers to copy any information manually.
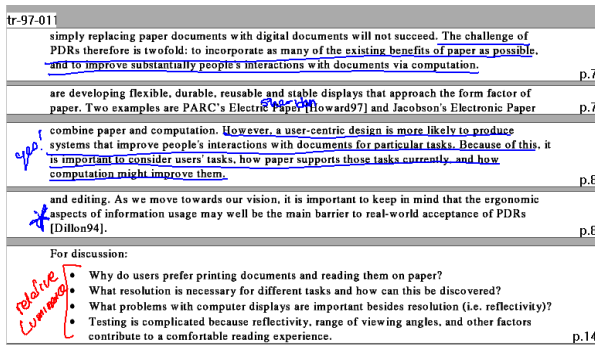

Figure 1.. The. Reader.s. Notebook. shows. annotated clippings of documents laid end-to-end.

Clippings are derived from the bounding boxes of annotations by expanding them horizontally to the width of the page, and by expanding them vertically to include complete words. Clippings that overlap are merged together. The Reader's Notebook presents clippings from annotated documents laid out end-to-end on a page. Clippings are labeled with document title and page number, and act as links to the underlying page.

The Reader's Notebook can display clippings from one document or from all documents, and can be sorted and filtered. By default, clippings are sorted by time, analogous to a paper notebook. Alternatively, clippings can be sorted by page number, analogous to a summary of a paper document. Finally, readers can filter the clippings by ink color to search for different kinds of marks or to group related items together.

MARGIN LINKS
XLibris monitors readers' annotations and creates links to related passages in the margin (Figure 2). Margin links allow readers to identify related information in the context of their reading instead of as part of a separate task. Margin

links also promote the serendipitous information access typically provided by physical media. For example, visitors to libraries often find the desired information not in books found through the file catalog, but in books located near them on the shelves.
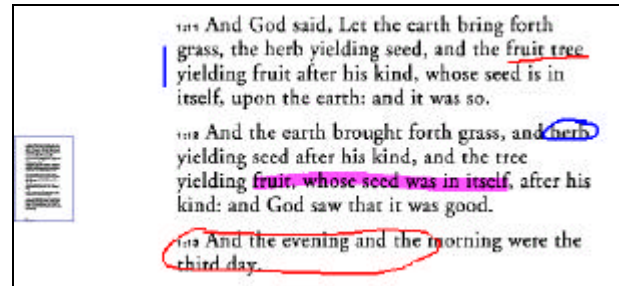

Figure 2. Examples of highlighting, underlining, circling, and margin annotations. Each annotation generates a query. If a good match is found, XLibris adds a margin link (rectangle on the left) that shows the thumbnail of the destination page

XLibris computes queries from free-form ink annotations by determining which text they refer to. XLibris also recognizes several types of annotations: underlined words, circled words, circled passages, and marginal annotations. Underlined words and circled words translate into queries that emphasize those words over others in the same sentence. Circled passages and margin annotations translate into queries that search for similar phrases.

XLibris uses Verity's search engine to evaluate these queries and find the best matching passage. If the similarity value (or "belief" score) of the best match returned by the search engine is above a certain threshold, an anchor is displayed in the margin.

Link creation does not disrupt the reading process. The reader is free to disregard the suggestion and to continue reading. The intent is to provide a modeless link suggestion mechanism, and to allow readers to follow the links at their leisure, rather than at the time that the links are identified.

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