

# Improving paper books: searchable books

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## ABSTRACT

Much of today's information is digitised; representation of information is increasing becoming digital. Yet, paper books remain popular, as many readers prefer the reading experience that paper books provide that digital interfaces cannot. In this paper, our aim is to improve users' reading experience by augmenting books with digital functionalities. We conducted a user survey study to identify features that users desire. The study highlights one specific feature – content searching within books, and we discuss three design choices to incorporate digital searching in paper books.

## Author Keywords

Books, User Survey, Digital Search.

## ACM Classification Keywords

H.5.2 Information interfaces and presentation (e.g., HCI): User Interfaces – *User-centered design*.

## General Terms

Design, Human Factors.

## INTRODUCTION

Since the dawn of books, inscribing text on papers has traditionally been the primary medium for conserving information. Historically, paper has been the preferred option because of its availability, lightweight, as well as its low-cost economic value and other benefits. Over many of the past centuries, countless number of writers have contributed immense volume of literatures on papers and the literatures have been passed down many generations. Throughout this extent of time, literature readers have developed proficient skills of comprehending paper-based information. Subsequently, the ability to read has become one of the common skills of many people today.

As we shift towards the new era of digitising information, the trend of conserving information is also changing. Already, a large amount of today's information is stored in and pre-

sented on digital devices, web pages for example. Also, device capacity nowadays allows the storage of over hundreds or thousands of digital books on a single device. Integrated with network capability, users can access millions of digital books online. Compare to paper-based literatures, access to digital materials is far quicker and easier. In summary, digital technology offers many possibilities and functionalities that paper interfaces cannot offer [3].

Both paper-based and digital books have individual inherent benefits. Paper books, as a traditional medium, offer tangibility as well as many affordances [4]. For instance, regardless of a book's content, when the reader picks up the book, he/she automatically knows that the content is presented in sequential pages (i.e. text that spans more than a page is subsequently continued on the following page) as well as how to access a desired page (by either simply leafing through and turning pages until the desired page or approximately opening the book to a page close to the desired one). Digital devices, on the other hand, has the benefit to download or copy e-books from other devices, without losing any quality as the content is represented in digital form. Each medium has benefits that the counterpart cannot offer, and yet, one medium's benefits cannot be adopted by the other. In this paper, our aim is to find ways to improve users' reading experience by incorporating digital functionalities into paper books.

Many researchers have suggested various methods and novel concepts to improve users' reading experience. For instance, Watanabe et al. [5] presented "BookiSheet", an interface that consists of bend sensors for scrolling through digital content, which provides the tangible sense of turning pages in a book by bending. The authors have envisioned combining the interface with a flexible display to provide readers the impression of a real book. Similarly, a publication by Fujinami and Inagawa [1] suggested embedding sensors in paper books to detect page turning. When a user turns a page, the sensors detect the action and an external display show multimedia information according to the current page that the user is reading.

Numerous ways to improve users' reading experience with digital technology have been suggested in research. Instead of focusing on the technology, we adopt the *Human-Centered Design* (HCD) methodology (*Hear, Create and Deliver*) from IDEO [2]. We begin with the "Hear" phase by understanding users' needs and investigate the dire issues that we must solve for the users. We thus conduct an

informal survey with potential users (colleagues from our university) to identify the features that people want to have when paper interfaces are integrated with digital functionalities (cf. section: Survey Study). From the survey study, our interviewees helped us to identify that a digital search functionality in paper books should be considered. We therefore focus on this feature and we discuss three design choices to implement searchable books, as well as illustrate a prototype of using an external device to facilitate digital searching in paper books.

### SURVEY STUDY: UNDERSTANDING USERS' NEEDS

As an initial study, we recruited seven colleagues (6M, 1F) from our university; six postgraduate students and one post-doctoral researcher, and they all have background in computer science. The survey was conducted as informal discussions with the interviewees individually or in pairs. Each discussion lasted for about 15 to 20 minutes. We have prepared three pre-selected questions (see below) to start the discussion. After asking each of the questions, based on the subjects' responses, we further inquire their reasoning by asking them open questions.

For the rest of this section, we summarise the interviewees' answers from the discussions (see figure 1 for the summary).

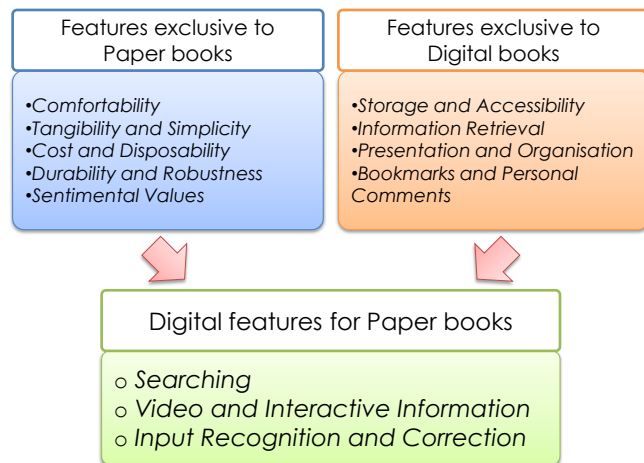


Figure 1. A summary diagram of our interviewees' responses

#### •What features do paper books offer that digital books do not?

**Comfortability:** Many the interviewees mentioned that reading information on paper is more comfortable because: (1) text on paper is illuminated from natural ambient light, thus easier to focus; while information on backlit displays are difficult to read for a long period. (2) Paper books are easy to hold since the material is lightweight and bendable, while digital devices are rigid and fixed in shape. (3) Paper has been predominant for many generations; many people prefer to read text from an interface that they are familiar with. Furthermore, one subject explicitly mentioned that since his work involves much around with technology, when he reads books during his free time, he prefers an interface that does not remind him of technology and work.

**Tangibility and Simplicity:** All paper interfaces are tangible, as information is presented on a physical surface. Due to the inherent characteristics of paper, the interface can only display static information; any content printed on paper is fixed and permanent. As a result, paper interface provides an affordance of what readers see on a page is what they get and expect no extra information (i.e. the concept of What You See Is All You Get). This subsequently simplifies readers' expectation, as there is no hidden sub-functions.

**Cost and Disposability:** The monetary value of a book depends on its prestigiousness. Many books are cheap and designed to be disposable. Magazines for instance, once they are read or outdated, they are recycled. Because of the low cost values of books, readers do not worry about misplacing the reading material. On the contrary, the current costs of electronic book readers are much more expensive than paper books; consequently, users often need to handle the devices with care. Furthermore, digital books induce two costs: a cost for an electronic book reader and another separate cost for the digital book content.

**Durability and Robustness:** The nature of paper allows books to be manhandle with carelessness. Paper books can be thrown, dropped, and smashed, as long as the action does not cause the printed information to fade. One of the subjects jokingly told us that he would not hesitate to pick up a book to hit a fly or a mosquito, but he would not do the same with an electronic device.

**Sentimental values:** Beside monetary values, people attach sentimental values to paper books. For example, books are often used as gifts; a book given by someone special is unique to the receiver. Thus, a physical book can be seen as a irreplaceable memento. On the contrary, people attach less sentimental values to digital books, since digital information exists virtually and it is easily duplicated and recovered.

#### •(Vice versa of the previous question) What features do digital books offer that paper books do not?

**Storage and Accessibility:** Current mobile devices have immense data storage capacity. A single device can store over thousands of books. As a result, it provides users the convenience of able to access a library of books on one device, i.e. virtual content increases while the physical characteristics remain unchanged. Furthermore, as ubiquitous computing proliferates, many devices nowadays have network capability; this allows users to access online digital books. Via a mobile network connection (like HSDPA), users can access and download digital books from any location.

**Information Retrieval:** Results from our survey show that all of the interviewees recognised keyword searching on digital books is a prominent advantage that paper books do not offer. Traditionally, paper books have a list of indexes (usually at the end of the book) to help readers find information quickly and easily. Yet, this functionality is only useful if the search keywords are indexed. Whilst with digital books, since information is digitalised, indexing the entire content

is possible. As a result, the list of indexes for digital books is much larger.

*Presentation and Organisation:* Digital content is separate from its presentation. For example, users can change the font and colour of the text without changing the book's content. As a result, users can personalise interfaces according to their preferences. Beside presentation, users can also personalise the ways of organising their libraries. For example, users can sort books according to genres, authors, or languages via a call of the sorting function.

*Bookmarks and Personal Comments:* With the suitable input interface, digital book readers can support functionalities that allow users to annotate paragraphs with personal comments or to leave bookmarks in any pages. These features can be hidden or removed without affecting the original content.

**•If paper books could adopt digital books' characteristics, what features (or functionalities) should be included?**

*Searching:* All of our interviewed subjects suggested searching for information by keywords is a fundamental feature, especially for reference books (like textbooks). People often want to retrieve text that was previously read or to search for specific information in a book without browsing many pages. Manual search is time consuming, as it requires flipping through numerous pages; instead, digital search is convenient, precise and accurate, as the system finds the exact locations of the information in the book. Furthermore, multiple search terms can be inserted at once for retrieving related information, and by matching all the terms, digital search can provide higher precision. However, since multiple results are often returned, designers must select an appropriate output to ensure results are presented in a readable manner. Other than using keywords, some interviewees also suggested the use of audio speech or drawing doodles to search for information in books. For example, a user scribbles a sketch, and then the system analyses the input sketch and returns figures that are related to the drawing.

Another suggested search feature was selecting text from the book and then search for additional information on the Internet (i.e. web search based on the information from the book). For example, while a user is reading a book, the user may want to search for definitions. The user can select a certain passage on a page and perform an online search (like a dictionary or Wikipedia) to find additional information about the selected text.

*Videos and Interactive Information:* The second feature our interviewees suggested was displaying videos on paper. Often, ideas can only be expressed in videos; nevertheless, this option is limited in paper books because of the nature of paper. Paper interfaces can only offer static information, like text and still images. Currently, to simulate the display of a video on paper, sample frames from the video are used to express the story. However, the experience of viewing sample images from a video is not the same as watching the

entire video, as much of the information is lost. Web pages for example, when viewing a video on a webpage, we can play, pause, rewind or fast-forward the videos; however, if the webpage was printed on paper, we lose the controllability as well as the videos.

Following the idea of embedding motion pictures in books, our interviewees also suggested the adoption of interactive information in books. For example, additional information should only be shown on demand, like videos should only play on users' request. This gives readers the control of information flow and avoids disturbances by the extra content.

*Input Recognition and Correction:* Other than displaying information, books can also be used for capturing information. Notebooks for example, people often jot down ideas or draw figures on notebooks. Our interviewees suggested the idea of having an input interface that users can write text or draw figures on paper and the system can automatically correct any mistakes, like changing a freehand drawn circle into a perfect circle.

Besides identifying features to improve paper books with digital functionalities, other suggestions include improving the experience of reading electronic books. Physical form factors were suggested; for example making digital book readers more paper-book like by using bendable and lightweight components to manufacture the devices, incorporating the smell of books, etc.

Although many of the suggested features from study are still far-fetched with the current technology, one particular suggestion, information searching within books, is possible.

## DESIGN CHOICES FOR SEARCHABLE BOOKS

Many (paper-based) books have an index section with a list of pre-selected indexed words. Traditionally, searching for desire information in a book requires the reader to find indexed terms and the corresponding page numbers from the back-of-the-book index. Nonetheless, if the search terms are not indexed, the alternative approach is readers must exhaustively browse through pages of content until the information is found, but there is no guarantee that the information will always be found. On the other hand, since information can digitised, a digital reader can index the entire content. Similar to web search engines, an indexer converts the books' entire content into a full inverted index. Once content is indexed, users can enter search queries and retrieve related information at an instant speed. This method is convenient and timesaving as most of the laborious work (like manual searching) is done automatically.

Consequently, we discuss three related design choices for incorporating search facilities into users' reading experiences.

1. **Electronic Book Readers :** As the name implies, the straight forward approach to incorporate search function in books is to make books fully digital and use an electronic interface to support user input and information output. The idea of using an electronic device to view digital

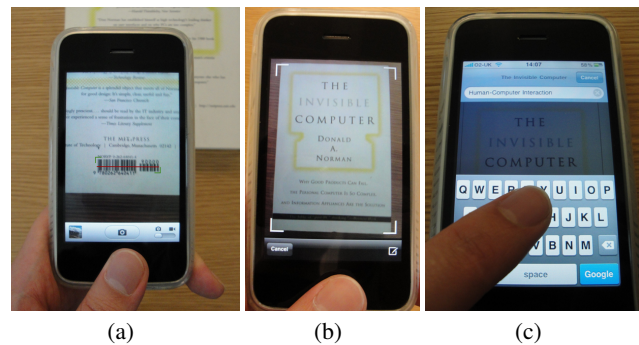
books has existed for many years. Earlier versions of electronic books use personal computer interfaces, like desktops or laptops, as a medium to output books' content. As technology evolves, more people are reading digital books. In the recent years, mobile electronic book readers (also known as e-book readers or e-Readers) have gained much popularity in the book industry. The functionality of searching for information in e-book readers already exists in commercially. For example, the built-in e-book application of Apple's iPad has an integrated search function for users to locate information in a book. By entering search terms, the system automatically retrieves related information from the book that the user is reading.

2. Paper Books + Embedded Interactive Interfaces: As digital devices become pervasive, everyday objects are embedded with computing components. Thus, an alternative approach is to embed digital interactive interfaces within paper books. By doing so, paper books keep most of their affordances, with the minimum attachment of digital components for searching. Unfortunately, the technology today is insufficient to implement this concept as a functional unit. The implementation of this concept requires components that do not affect the original book's form factors like shape, size and weight. Moreover, the components must facilitate user input/output as well as data storage.
3. Paper Books + External Device: The final concept is having books remain paper-based; instead, an external device (like a mobile phone) is used as an interface to perform the information retrieval task. In other words, the external device acts as a module to bridge users' search queries, the books' digital contents, as well as the search results.

#### A PROTOTYPE OF PAPER BOOKS + EXTERNAL DEVICE

The ubiquity of feature rich mobile phones has afforded us to utilise them for a variety of purposes. As mentioned above, for our current context of augmenting a paper book with content searching facilities, such mobile phones pose simple yet powerful interaction experience. Users can maintain and enjoy all the physicality of a paper based book, yet receive the most desirable digital search feature by linking a book with its digital representation through a mobile phone. There are multiple choices to perform this linking operation, e.g., (2D barcode, NFC tags, Object Recognition, etc). Using one of these techniques, a user can submit book's information (like the title or the ISBN) and a search query via a mobile phone, and then the phone transmits the information to an online database for search results. For example, figure 2 shows a simple application where the camera can scan an ISBN barcode of a book to link it with its digital representation to offer digital searching feature. Alternatively, books can be embedded with NFC tags, thus users can use an NFC reader to identify books by holding them close to each other.

This approach of using an external device for searching allows books to remain fully paper-based, without the need of altering the original interface; thus, all paper-based affordances remain intact. Moreover, the search function is only employed when users demand it; hence, the function-



**Figure 2.** An illustration of book content search via a mobile phone. Figure 2(a) shows the application capturing the book's ISBN barcode to identify the book, while figure 2(b) illustrates using the book's cover page. Figure 2(c) illustrates a user entering a search query after the application has identified the book.

ality is optional and it is completely hidden if search is not needed. However, the utilisation of an external device has inherent disadvantages: the functionality depends on the external device to have the required application pre-installed, and it also requires the database to have an indexed copy of the book being searched.

#### CONCLUSIONS

In this paper, we have discussed the design spaces to improve reading experiences by augmenting digital functionalities into paper books. We have reported our findings of user needs implicated from an informal qualitative user study by following a human centred design methodology. Our study highlights one specific desirable feature - content searching within books to be available in all reading experience. Consequently, we discuss three design choices with varying degree of digitisation and augmentation. Finally, we present a simple yet practical solution out of these design choices to augment a paper book with digital search services through an intermediary device to ensure a seamless and compelling reading experience.

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