gBook: An e-Book Reader With Physical Document Navigation Techniques

Jesse Burstyn
Human Media Lab
School of Computing
Queen's University
25 Union Street
Kingston, ON K7L 3N6 Canada
5jb13@queensu.ca

M. Anson Herriotts
Human Media Lab
School of Computing
Queen's University
25 Union Street
Kingston, ON K7L 3N6 Canada
4mh25@queensu.ca

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Abstract
In this paper, we present gBook, a prototype for a new style of e-book reader that uses flexible inputs and page orientation to simulate the properties of reading a bound printed book. This project takes into account some of the known methods that people use when reading books, to make page navigation correspond more to that of paper-based books. The underlying assumption is that doing so will improve the learnability of navigation, as well as the usability by allowing more casual methods of page navigation.

Keywords
Organic user interfaces, gesture input, eBooks, mobile computing, human factors, document navigation

ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): Input devices and strategies, Interaction styles

General Terms
Design, Human Factors

Introduction
Although the paper bound book has been in use in the Western world for almost two millennia, digital versions

of documents such as books and periodicals are now becoming increasingly widespread. With this increased popularity, companies such as Amazon, Barnes and Noble, and Sony have recognized a potential market for introducing dedicated hardware for purchasing, storing, viewing and navigating these digital documents utilizing e-paper display technologies. While their products are innovative commercial solutions, they are ultimately alike in their main presentation: providing a static display of individual pages with discrete methods of navigation.

The outlook of only providing a single screen and digital input misses many of the affordances present when reading paper documents. While not necessarily the most efficient, techniques such as folding and flipping pages are ingrained gestures that are lost with this new medium. In addition, viewing content on a single rigid surface, with large display sizes, does not provide the flexibility nor the portability that mobile devices require.

This paper proposes a style of digital document interaction based on the principles of organic user interfaces [6]. We present gBook, a flexible two-page e-book reader that recognizes page-flipping motions to navigate through pages.

How People Read

The main motivation for designing gBook was the re-introduction of methods of interaction that people utilize when reading paper books. Movement through paper documents is demonstrated through its automaticity and speed. In comparisons between digital and physical book navigation, O'Hara and Sellen [9] noted that physical page turning was often anticipatory. Subjects used a second hand to start turning a page before it was fully read, in an attempt to minimize the break in continuity between the content. In many cases, these motions were so automatic that partial or even complete page flipping occurred prematurely; gaining subtle peek of the contents on the next page. Contrast this with existing e-book readers where navigating between pages is an intentional act of pressing a dedicated directional button. While the resulting content change may be faster, it does not recreate the fluidity of physical page flipping, resulting in an interruption of the reading process.

In order to recreate page-flipping motions, the shape of our hardware needed to resemble that of a physical book. However, this was not the only motivation in doing so - having two panels of content accommodates the way people read and understand the meaning of text. Underwood [11] emphasizes that regressive saccades (sudden eye movements backwards in the text) while reading are influenced by several different factors related to the difficulty of the text. Just and Carpenter [7] suggest that regressions facilitate deeper comprehension by providing a "review of previously read text to re-encode it or process it to deeper levels”. By designing hardware to have two displays and allowing peeking between pages - making content more immediately and continuously viewable - readers can better accommodate their processes of reading. As a result, they may gain a greater understanding of the viewed material.

Related Work

Our work draws inspiration from previous attempts at navigating digital documents with the affordances of physical methods. Liesaputra and Witten [8] suggested that "the physical characteristics of a document . . . communicate ambient qualities" in their design of a software interface for reading e-books they called Realistic Books. Compared to static e-books, this presentation of a digital document, with visualizations of page turns and other qualities of a real book, was found to have a beneficial impact on the navigational skills of its users. However, its usage of both digital input and a separate planar display has a level of detachment from input to the display of information.

Bookisheet by Watanabe et al. [12] implements a flexible sheet to represent the combined surfaces of an open book. Bending the sheet to various degrees of pressure simulates the method of quickly browsing through content by 'leafing' through multiple pages using the friction of a thumb and the mass of paper pages.

Chen et al. [1] illustrated the importance of two separate displays when creating an e-book reader, as their design "offers a compromise between increased screen real estate and a flexible and convenient form factor". Their dual-display interface also implements "lightweight, gesture based controls", using a similar philosophy as gBook. Their device, however, was made mainly to accommodate viewing multiple documents at once, with the ability to detach the screens from each other.

gBook attempts to bring many of these techniques together to provide a cohesive interface for reading e-books in a manner that is flexible, comfortable, and recognizes the subtleties of physical book navigation.

Implementation

Our computer-generated book, projected onto the gBook hardware, is based on Ruben Swieringa's Flex Book project [3], which was modified to allow for multiple control inputs instead of mouse gestures. Additional Flex[1] code was added to resize and move the page objects for tracking and projection onto the physical surface.

gBook itself is a wireless display and interaction device that uses Bluetooth connectivity, infrared tracking and projection. The hardware on the back of the book consists of two disassembled Nintendo Wii Remote[2] accelerometers, to track the orientation of the left and right pages, and two infrared LEDs on the top left and bottom right corners, to track position and page spread for the projected image.

The rotation/orientation of the Wiimotes is tracked using GlovePIE scripts [4], which converts Wiimote rotation into gestures that control page flip movement. Peek, flip, and navigation gestures only require the rotation (calculated with respect to gravity) of the Wiimotes, simulating the actual orientation of a page.

1 Adobe Flex 3. http://www.adobe.com/products/flex

2 http://www.nintendo.com/wii/what/controllers

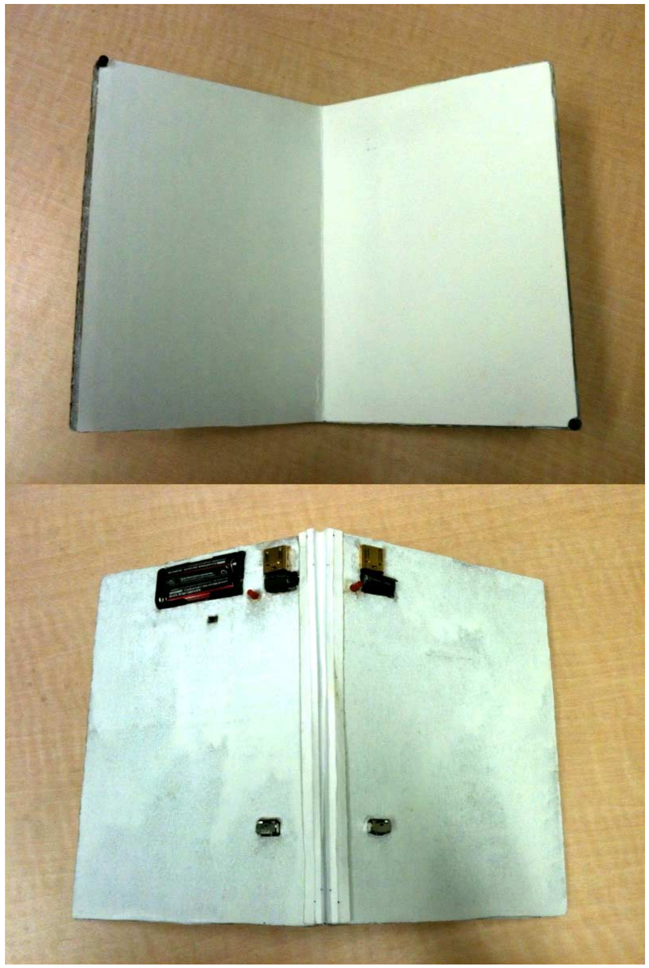

Figure 1: The gBook prototype hardware.

For the purpose of projection, we track the location of gBook's physical surface with a PlayStation Eye[3] camera, modified with a visible light filter. The IR LEDs are tracked through Community Core Vision (CCV) [2], which sends the data using the TUIO protocol [10]. Although CCV was designed for tabletop surfaces it can be utilized to track dots in a 3D space. The software to interpret the tracking information was written directly in Flex through XML-sockets, breaking down the TUIO data into just the dot IDs and coordinates. This simplified data is then used to determine the location and dimensions for projection of the pages onto gBook's physical surface.

3 www.us.playstation.com/PS3/Accessories/SCPH-98047

Page Navigation

One goal of our page gestures was to mimic navigation of a real world book through simple use of gravity and physical inertia to turn pages, while at the same time responding to intentional gestures by the user.

To do this, the GlovePIE scripts recognize a range of page orientations each having their related reactions. The physical page orientations range from low, or open book, to high angles that cause page navigation (Fig 2). When the user tilts the left or right page up, so as if to turn the page, gBook responds by animating a page turn. At a partial angle the book reacts with a partial page turn (or peek), while continuing the rotation causes a complete page flip. Pages continue to flip as long as the user holds the physical page at that angle.

The initial settings proved to be too much effort for a user to turn a single page, and were adjusted to lower angles. However, due to this smaller range, page peeks are more limited, and do not occur as easily. This can cause a premature page flip when attempting a peek, reflecting real life slips.

Figure 2: Projection onto the device, showing a large page peek in progress.

Discussion

gBook presents the basis for a new method of interacting with digital documents. Recognizing the orientation of the flexible sections of the device to simulate a one-to-one correspondence of digital pages provides users with interaction techniques that are immediately transferable from knowledge of handling a bound paper book. Responsiveness to gravity, and the hinged panes of content provides users with an affordance of how to navigate between pages. Additionally, this two-paned flexible format affords increased portability without sacrificing display area, by allowing the device to be folded into a smaller size.

Preliminary user feedback suggests experiences with gBook were positive and constructive. Sample users found that using moving the book to simulate page movement felt more natural than using directional buttons, and the device felt like holding an actual book. They also commented that the ability to subtly peek at the contents of adjacent pages mimicked the way they would read content. On the flip side, some users noted that the panels of the device were not as flexible as they would have expected and the connecting hinge felt more like the spine of a textbook than that of a paperback novel. Ultimately, users informed us that they looked forward to dedicated e-book readers that allowed them interact with digital content with the comfort and feeling of a bound book.

Future Work

The gBook as outlined in this paper represents just some of the possibilities of page flipping gestures. However, there are many improvements that could be made, and many possible modifications and additions that would provide a closer metaphor to a bound book.

As discussed, the projection and tracking need further work, due to the limitations of Flex and the PlayStation Eye. This can be drastically improved through a more advanced tracking and projection system, similar to the one used by Holman et al. [5] in their PaperWindows system. To address the concerns of rigidity, the physical model itself could be more flexible like Bookisheet but without sacrificing the ergonomic feel of a bound book.

Integrating page flexing, in addition to the orientation gestures, would improve the interactive properties that are analogous to a real book. This also creates the possibility of adding many different gesture techniques that would simulate the range of possibilities available when reading a real book, creating much more fluidity in both regular page traversal, and looking forward, bookmarking creation/retrieval.

The ability to have a larger surface area without the need for a large monolithic form factor is one of gBook's strong points. Unfortunately, this is not fully taken advantage of. One consideration is to allow the device to be held flat and rotated 90 degrees while a zoomed in view of the current content is displayed. This would provide the user the benefits of a large single display, as seen in commercial e-book devices, without sacrificing portability.

Another improvement would be to give additional visual cues as to the current location in the document in the ambient methods that a physical book provides. A visual 'accumulation' of pages on each side of the surface, in a similar method as Realistic Books, could subtly communicate how much content the reader has traversed through.

References

[1] Chen, N., Guimbretiere, F., Dixon, M., Lewis, C., and Agrawala, M. Navigation techniques for dual-display e-book readers. In *Proc. CHI 2008*, ACM Press (2008), 1779-1788.

[2] Community Core Vision. http://ccv.nuigroup.com

[3] Flex Book. http://www.rubenswieringa.com/blog/flex-book-component-beta

[4] GlovePIE. http://carl.kenner.googlepages.com/glovepie

[5] Holman, D., Vertegaal, R., Altosaar, M., Troje, N., and Johns, D. Paper windows: interaction techniques for digital paper. In *Proc. CHI 2005*, ACM Press (2005), 591-599.

[6] Holman, D., Vertegaal, R. Organic User Interfaces: Designing Computers in Any Way, Shape, or Form. *Communications of the ACM*, 51 (2008), 48-53

[7] Just, M.A., and Carpenter, P.A. A theory of reading: From eye fixations to comprehension. *Psychological Review 87,* 4 (1980), 329-354.

[8] Liesaputra, V. and Witten, I. Seeking information in realistic books: a user study. In *Proc. CHI 2008*, ACM Press (2008), 29-38.

[9] O'Hara, K. and Sellen, A. A comparison of reading paper and on-line documents. In Proc. of CHI 1997, ACM Press (1997), 335-342.

[10] TUIO Protocol. http://www.tuio.org

[11] Underwood, G. *Eye guidance in reading, driving, and scene perception*. Elsevier Science Ltd, Oxford, England, 1998.

[12] Watanabe, J. I., Mochizuki, A., and Horry, Y. Bookisheet: bendable device for browsing content using the metaphor of leafing through the pages. In *Proc. UbiComp 2008*, ACM Press (2008), 360-369.