Supporting Effective User Navigation in Digital Documents

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Abstract
Electronic documents such as PDFs are becoming increasingly popular as we move further towards the notion of the paperless office. The harsh truth however is that e-documents differ greatly from their physical paper counterparts, with many users opting to print them before reading. This paper describes several novel implementations that utilize a technique known as 'lightweight interaction'; a term that describes activities that can be performed without excessive cognitive attention. Incorporating tools into digital document readers to aid users in day-to-day tasks will enhance their performance and hopefully increase user uptake of digital reading. My research on this topic centers on several areas of document navigation, focusing specifically on current physical (paper) practices, in order to enhance their digital equivalents.

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Introduction
With the introduction of the personal computer came predictions of the 'paper-less office' [1,3] promising the redundancy of paper from everyday office related tasks. However, after more than 20 years [1] and despite the wide-spread availability of digital documents, consumer paper usage is increasing. The main problem with the digital document paradigm is the differences they pose from their physical paper counterparts [3]. The tangible properties of paper (e.g. that it's light, thin and flexible) afford many actions that are not possible on digital equivalents. Activities such as folding, ripping and flicking all contribute to the ease in which physical documents are manipulated and are difficult to replicate in digital media.

A useful way of encapsulating the affordances that paper documents offer is by 'lightweight navigation'; a term coined by Catherine C. Marshall in 2005 [2]. Marshall defines the term 'lightweight' as navigation that occurs either when people reach a particular page or when they move within an article in a way that is so unselfconscious that they aren't apt to remember it

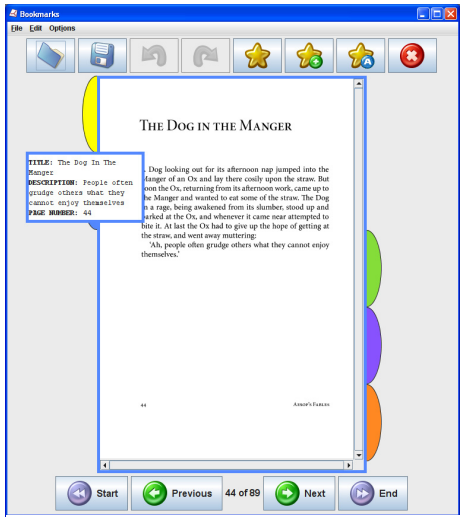

Fig 1: The Visual Bookmarking System

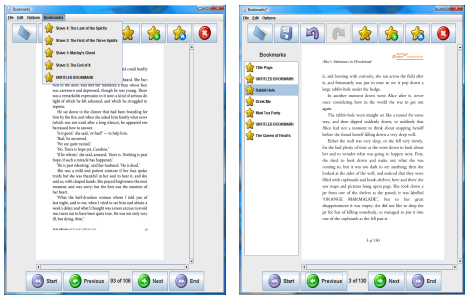

Fig 2: The two additional user study implementations; un-ordered menu (left) and ordered list (right)

later. Although this type of activity is common in physical documents, it is rarely seen in digital navigation. Marshall speculates however, that this concept of 'lightweight' interaction can be also be applied to digital technology, but does not give any concrete evidence to support it. The goal of my PhD then, is to prove by example that lightweight interaction is indeed possible on the digital level and to consequently define the digital equivalent of the term.

There are many aspects of computerized technology that far exceed the capabilities of paper (i.e. searching, zooming etc) and by paying closer attention to the possibility of 'lightweight' navigation (and also its corollary: 'heavyweight'), digital document software can not only incorporate the physical affordances of paper but also improve upon it, by surpassing its limitations. It is for this reason that I feel this work is an original contribution to the field of HCI.

Significance of the Topic

The interactional properties of documents have been a recurring theme in HCI research. My PhD will serve to bridge between the qualitative research of O'Hara, Sellen and Marshall [2,6] and the technical approaches exampled by Schilit and Golovchinsky [7].

Whilst lightweight interaction has been noted as a key advantage of paper by qualitative researchers, systems researchers have emphasized the development of innovative prototypes. Unfortunately, there is only a weak relationship between these two approaches: digital interaction designs are not justified directly from principles noted in paper work, and the evaluation criteria are also only informally related to observed needs and behaviors. Furthermore, there is an absence of a coherent understanding of effective electronic interaction: individual prototypes have not developed into a schematic body of design knowledge. My hypothesis is that effective electronic interaction for digital documents will demonstrate similar properties to paper interaction. However, our understanding of how to reify 'lightweight' is currently weak, and the mapping from paper to digital is not straightforward. I plan to arrive at a more structured and principled approach to designing interaction for digital documents. In the following parts of this proposal, I outline the progress made to date with example systems.

Lightweight Implementations

Placeholders

Placeholders in physical documents require minimal effort. Placing and removing bookmarks can be so unselfconscious that users are likely to do it without thinking, making it a perfect example of 'lightweight' interaction. Unfortunately however, the equivalent tools on digital document readers have long been identified as unintuitive and hence suffer from poor rates of use. To improve the digital placeholding process, I have implemented a system that uses visual bookmark 'tabs' to replace the commonly used list method, in order to make it more 'lightweight'. The Visual Bookmarking system (Fig 1) has been designed to act in the same way as a telephone directory; i.e. bookmark tabs that appear sequentially *before* the current page appear on the top left, whereas those that exist *after* the current page appear on the bottom right. This novel interaction provides a handy visual overview of every bookmark in relation to others in the document. Clicking on a colored tab will navigate the user to the bookmarked page. Hovering the mouse over a bookmark will produce a 'pop-up' containing information about it.

To evaluate the implemented system, a small comparison study was undertaken to collect subjective reviews from a set of target users. To achieve this, two additional systems (Fig 2) were implemented, modeled

on existing digital placeholding techniques; un-ordered menu (based on web favorites) and ordered list (based on document reader bookmarks). The results of this study produced promising results, proving that the visual approach was the most popular bookmarking approach with an average ease of use rating of 7.7 out of 10, compared with only 4.3 and 6.4 out of 10 for the un-ordered menu and ordered list respectively. This work has resulted in a publication [4] at ECDL 2008, which also won the *best paper award*.

Notes

Although the Visual Bookmarking System is vastly more 'lightweight' than most digital bookmarking methods, it still lacks the easy movement and manipulation that comes with paper bookmarks. On the physical level, scrap paper and Post-its can be used to mark a place in a document, as well as doubling up as a note taking facility. The Notes system has been designed to act much in the same way as a real book sitting on a desk by incorporating the same type of interaction. On one side of the 'desk' sits the PDF while the on other are 'piles' of Post-it notes. These inexhaustible piles of Post-its can be dragged on to the PDF, the desk itself, and even partially on the document to create a make-shift bookmark. This functionality essentially means that one tool (i.e. a Post-it) can perform two functions: annotation and bookmarking. As with the visual bookmarking system, Post-its that act as bookmarks (i.e. those that stick out of the book) change position depending upon which pages are currently open, i.e. turning a page with a Post-it bookmark on the side will cause it to *flip* to the other (Fig 3). As this is a work in progress, I have not yet performed an evaluation study.

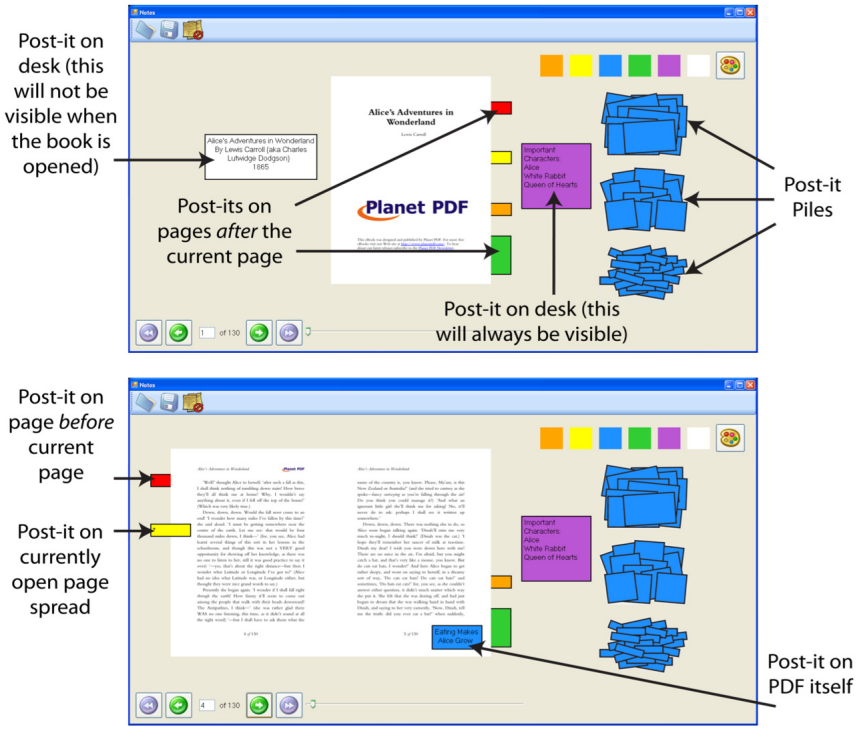

Fig 3: The Notes System with the book closed (top) and with the book open (bottom)

Indexing

Conventional printed indexes give users quick and easy access to information in a document. However, traditional indexing in both paper and digital forms can be considered relatively 'heavyweight', due to the time and thought required to navigate within the document. An alternative to indexing in digital documents is text search (Ctrl+f in Windows), which despite being fast in execution, lacks the visual overview of printed indexes.

To make the digital indexing process more `lightweight', I have implemented an index builder that facilitates rapid user-specified indexes eliminating the need for physical reference. In addition to this, color and size have also been used to illustrate the areas of the document with the highest number of keyword occurrences. Fig 4 shows three such visualizations where size (the bigger the link the more occurrences)

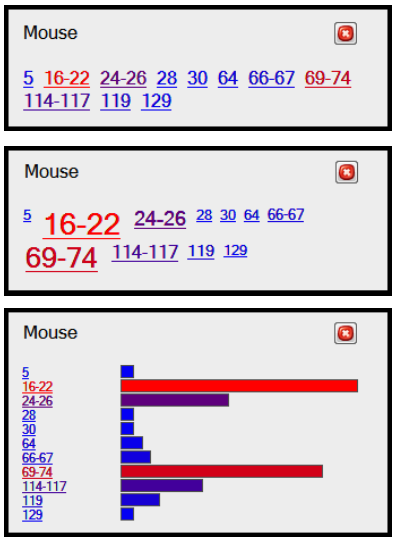

Fig 4: The Color Tag (top), Tag Cloud (middle) and Graph (bottom) visualizations from Visual Index System

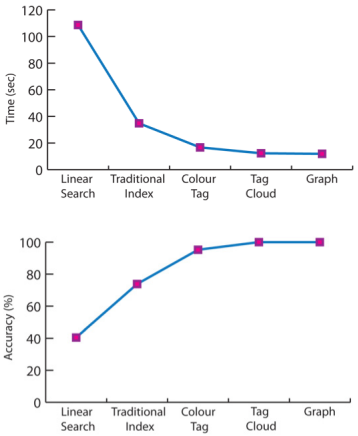

Fig 5: Quantitative results from indexing study. Task timings in seconds (top) and task accuracy in percent (bottom)

and color (from red; a hot result, to blue; a cold result) have been used. My method avoids the need for navigation to a separate index at the back of the book (as on paper) and minimizes within-document navigation when compared to digital point-to-point alternatives. I anticipate that this presentation is 'lightweight', in that user navigation away from their current location in the document is minimized.

The main aim of the system was to integrate the speed of digital search with the visual overview of keyword locations that comes with document indexing. I anticipated that this would increase the speed with which users can locate relevant information and improve the effectiveness of reading the text. To investigate these issues, a pilot study with fourteen participants was performed to gain both subjective reviews by means of questionnaires as well as speed and accuracy statistics from a set of document tasks. Two baseline systems were implemented to act as comparisons to the visual approaches: linear search (ctrl+f) and a non-visual index builder (the standard index builder with no color or size cues). The results from this study (Fig 5) confirmed the impact of custom index builders over standard sequential search in both the timed tasks and subjective user reviews. In addition to these results, it was also discovered that the custom index builders significantly increase the accuracy in which users can locate relevant material in a document. This work has been further reported in [5]

Conclusions

Catherine Marshall's principle of lightweight interaction is as yet poorly understood in the context of digital documents. If it is possible to achieve the cognitively lightweight style that she envisages, it would increase the usability of digital systems that employ it. To prove this hypothesis, I have implemented several examples of lightweight digital techniques and have so far achieved some promising results proving that in many cases a lightweight approach improves user satisfaction and increases task performance. The topic of document navigation is an important one in HCI. A number of highly respected researchers – including Kenton O'Hara, Abigail Sellen, Gene Golovchinsky, Cathy Marshall – have investigated the issue, and many questions remain unanswered. The overall goal of my PhD is to further identify shortcomings in digital document reader design and improve them by means of lightweight interaction. In doing so I hope to identify the characteristics of lightweight design and eventually use them to create a digital definition of the term. This classification can then be utilized in future implementations by software designers which is why I feel my work in this area will be a valuable asset to the HCI community.

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