Designing the Reading Experience for Scanned Multi-lingual Picture Books on Mobile Phones

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ABSTRACT
This paper reports on an adaption of the existing PopoutText and ClearText display techniques to mobile phones. It explains the design rationale for a freely available iPhone application to read books from the International Children's Digital Library. Through a combination of applied image processing, a zoomable user interface, and a process of working with children to develop the detailed design, we present an interface that supports clear reading of scanned picture books in multiple languages on a mobile phone.

Categories and Subject Descriptors
H.1.2 [**Models and Principles**]: User/Machine Systems – *Human* factors.

General Terms
Design, Human Factors.

Keywords
Mobile phones, iPhone, children, readability, interface, design, books, digital libraries.

1. INTRODUCTION
It is challenging to gain mobile access to digital libraries. Despite the broad acceptance of digital libraries, and the continuous growth in the use of small mobile devices, little has been done to marry the two – especially for children's use [10].

Recognition of the value of mobile access to digital libraries has been discussed for some time. Marshall et al. highlighted the value of mobile access, including the ability to perform on-the-spot research; engage in opportunistic access; use digital content in concert with others such as librarians, analysts, and colleagues; and the ability to interweave access with other activities [16]. Buchanan et al., described some early design work applying the Greenstone digital library to small screen mobile devices [4]. In

Figure 1: The International Children's Digital Library on an Apple iPhone. This shows the home screen with four books (in English, Arabic, and Mongolian) pre-loaded.

the case of children, anywhere, anytime access enables a broad set of learning and compelling entertainment possibilities [10].

However, the challenges of offering access on a small device, can make these benefits hard to achieve. As far back as 1995, there has been an awareness of how users' abilities to access library resources on the go would be limited by hardware resources, including connectivity, battery life, and screen size [3].

A range of solutions now allows adults to access digital libraries or read from a small personal collection of materials from their mobile phones. These solutions have been focused on smartphones and PDAs, which typically have larger screens than older mobile phones. Commercially deployed systems include Microsoft Reader, Mobipocket, and several applications for Apple's iPhone,. There have also been research efforts based on WAP [15]. These efforts have mainly provided raw text; systems that support images are rare [1][5].

Children's picture books are a challenging example of a class of material that typically has not been available in a usable way on mobile platforms. The very nature of a picture book is that the text and image have equal value in the experience of the book. If

Figure 2: The overview (left), page view (middle), and rotated page view (right). Using the device's accelerometer, the software automatically rotates the text and displays two pages in landscape mode, thus presenting a more complete view of the book.

the text and image were separated, then a crucial element of the reading experience would be lost. We have been acutely aware of these issues for the past seven years, through our work developing and operating the International Children's Digital Library (ICDL), a website of freely available, exemplary children's books from around the world [8][9]. Many of the books in the ICDL (available at www.childrenslibrary.org) are picture books. One of our primary goals has been to increase cultural understanding among the world's children through broad access to children's books from different cultures. Hence, it is crucial that we make the books available to readers in many different settings, including places where mobile phones are the dominant gateway to the internet.

However, the visual nature of many of these books makes mobile phone deployment a challenge. In addition, the ICDL books are in over 50 languages with about half of them in languages other than English, and many books available in multiple languages. Add the further requirement that the user experience must be simple enough to accommodate young children, and the challenge of devising a solution becomes more complex.

Because existing mobile applications do not address these requirements, we looked to our previously reported research, which was conceived to improve readability and support translation for reading scanned books on the ICDL website [17]. Our book reading interfaces, called "PopoutText" and "ClearText", essentially allow the reader to magnify just the text, while keeping it in the context of illustrations. PopoutText can magnify just the section of the image containing the text. ClearText separates the text from the image using natively rendered text, and enabling translation displayed in place. This uses image processing to determine the location of the text on the page and in-fill the areas occupied by the text with suitable background colors, so that a larger version of the text can be used.

However, even applying one of these solutions to cell phones is difficult because most phones just don't have large and high enough resolution screens to make these approaches work well as previously designed. Add in the poor computational power, sometimes indirect interaction through keypads, and small storage, and it is easy to understand why reading picture books on a mobile phone has never become popular.

With the advent of the recent generation of graphics-oriented touch screen "superphones" [14][18] epitomized by Apple's iPhone, many of these limitations have been lifted. Not only do these phones finally have much higher resolution screens (typically 320x480 pixels), but they also have substantial storage (several gigabytes at least), fast processors, excellent and responsive capacitive touch screens, and even accelerometers to make it easy to support landscape and portrait reading. Although the devices are currently relatively expensive (i.e. ≥ USD$200 in the United States), we fully expect the cost will go down, just as has been the case with past generations of devices. Thus, before long we anticipate being able to use this technology to provide usable access to digital library materials to children in developing countries [19]. Furthermore, there is already tremendous acceptance of the iPhone throughout the world. With over 500 million downloads of iPhone applications to date [6], this platform has clearly demonstrated its broad access. Amazingly enough, in the 4th quarter of 2008, iPhone users downloaded more software than the 1.6 billion other cell phone owners throughout the world [6]. Clearly this is an important trend, and understanding how it can be harnessed to effectively deliver data is crucial.

Furthermore, these phones, while not broadly available today, are frequently used very socially – with people sharing applications and listening to each other's music. These qualities, along with their very tactile nature are somewhat similar to digital library deployments in much more impoverished settings, such as those in an Indian village described in the StoryBank project [11].

In this paper, we first describe how our team adapted the ICDL interface for the iPhone (Figure 1). We then discuss what we have learned through its November 2008 public deployment in the Apple AppStore as a free application.

2. DESIGN AND USE

The Choice of Books

Our first decision in designing *ICDL for iPhone* was to focus on reading books, and not searching and downloading books. With that in mind, the application includes four books. Due to variations in the formats of the books, they cover a range of content and technical requirements.

One book (*Waldo at the Zoo*), shown in Figure 2, is a "board book" with just 12 pages of large pictures and very little text. Therefore the words of the story are large enough to be readable when presented as a single scan per page on the phone. However, the pages in this book are intended to be read in a two-page view. The next book (*Black Ear … Blonde Ear*) was more challenging as it has small text with multiple textboxes per page, and is written in two languages (English and Arabic) across 28 pages (see Figure 3). The third book (*Six Silver Stars*) is 20 pages, and is written in Mongolian. Like Waldo at the Zoo, many of the images span two pages. The final book, (*The Three Little Pigs*) is an historic 28-page-book with full-page color plates and multiple textboxes per page with black and white illustrations.

Partnering with Children

We began working with children early in the design process.. We worked with "KidsTeam", a group of seven children aged 7-11 years old using a process called *Cooperative Inquiry* [7][8]. This group works in our lab two afternoons a week, and two weeks during the summer to help us design new technologies for children. While the team is involved in a range of projects, for this project, the children were involved in the iterative design of the application over a 3-month period. During that time, the children explored the iPhones in general, sketched new ideas for the application, and used early prototypes of the application to consider new design directions.

Some of the key design and usability trade-offs that came up during the course of our design process follow.

Tap vs. pinch

The basic design of the application, as motivated by PopoutText, was to present an image of the book page scaled down to fill the screen of the phone. Since the text for most books would be too small to read, there would then need to be some interaction to display the text at a readable size. The standard way to scale or shrink things on the iPhone is to use a two-fingered pinch gesture. However, that gesture is really designed for scaling an object that fills the screen. Since the textbox being scaled did not fill the screen, and there could be multiple textboxes to select among, we instead decided to use a simpler single tap on a textbox to magnify it. When a book is first opened, there is an indication around the textbox with a label that says "Tap to enlarge text". When the user taps on the text, the textbox animates to show it is growing, and then standard sized text is rendered within the larger box (Figure 3). If the text does not fit in the box, then standard iPhone scrolling is used within the textbox to scroll the text. Then, tapping on the text after it has been enlarged shrinks it and the display reverts back to the original state.

There is one remaining issue with this interface which is that tapping on the background image advances you to the next page. With the current implementation, the behavior is different depending on where you tap (open/close text or go to next page), and this difference requires more user attention to manage. The planned solution for this is to eliminate tapping for page navigation, and instead implement better swiping to navigate pages. (The current swiping gesture is not recognized until the gesture is completed. A better solution that we are working on, is to have it work with direct manipulation so the page moves immediately under the finger, and then snaps to the next or previous page – much like the iPhone home screen.)

Figure 3: A page from "Black Ear … Blonde Ear" with the initial scan (left), the result of tapping on the left textbox to see the English (middle), and the result of tapping on the right textbox to see the Arabic (right).

Book Overview

We have found that it is valuable to give readers an overview of the book before the reading experience begins. This serves two purposes. First, it gives more information as a person makes a choice whether to read the book or not. Especially for picture books and for children, visually seeing the pages of the book can be an important deciding factor [8][9]. Second, even if the decision to read the book has already been made, it still sets clear expectations about the book – how long it is, how many pictures there are, and what the pages look like.

To implement this well on an iPhone, we created a simple scrollable grid of thumbnails, modeled on the interface of the built-in photo application. But when you tap on a page thumbnail, instead of panning to access the full-screen version, we perform an animated zoom in to the thumbnail. We have shown in other contexts the benefit of contextual animation to reduce cognitive load [12]. And others, such as Levy have discussed the importance of creating simple direct manipulation digital library interfaces that can eliminate the interruptions inherent in manipulating controls [13].

One interesting implementation note is that even though iPhone is known for its high quality zooming, there actually is no API to support zooming transitions between two objects. Even the iPhone home screen does not perform a semantically meaningful zoom transition as the animation always zooms into the center of the screen rather than into the icon that the user tapped on. To solve this problem, we used a general zooming transition library that was created by our partner, Zumobi (a creator of iPhone apps).

Two-Page Display

As was mentioned in the introduction, several of the books in this application were designed to be shown two pages at a time. The picture flows across two pages – which is displayed naturally in a paper book when the book is opened. On the desktop web version of the ICDL, we simply let the user decide whether they want to display one or two pages at a time – and thus let them make the decision regarding the trade-off between artistic integrity, and space requirements.

However, on the iPhone, we were hesitant to add even one more control which would clutter the tiny display. So instead, we took advantage of the accelerometer that is integrated in the device. When reading a book in portrait view, one page is shown. But when the device is rotated to landscape view, both pages from the two-page spread are shown, with an animated transition. In this fashion, we take good advantage of the aspect ratio of the display where one page typically wouldn't fill the landscape display anyway because the portrait aspect ratio typical of most books. Not only does this address the limitations of the display, it also engages children in an interactive experience they find enjoyable.

Use of ICDL on iPhone

Over the four months that ICDL for iPhone has been in the Apple AppStore, it has had over 75,000 uses from over 25,00 unique downloaders. About half of the use comes from the United States with use after that coming (in order) from the UK, Canada, Singapore, Australia, Japan, Hong Kong, Taiwan and the Philippines (among others).

3. USER FEEDBACK AND NEXT STEPS

We have received feedback directly from users through email and public forms. The biggest feature request is for more content, and the ability to select and download books on the device. Another request is to take better advantage of the capabilities of the device by, for example, supporting audio books that are integrated with the visual display. We are working on all of these things, so expect to see (free) updates to the application before long. Based on the nature of this feedback, it seems that the general approach is working and, given further development and content curation, the aims of the project can be more fully realized.

We have also been working with KidsTeam to expand the vision of the application to include *authoring* of new books, or modification of existing ones. This is another challenging and exciting new direction that we expect to report on next year.

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