Bridging book: a not-so-electronic children's picturebook

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ABSTRACT
We present and technically describe the implementation of a book prototype: the Bridging Book, a children's mixed-media picture-book that blurs the line between printed and electronic books.
Bridging book consists of a printed book and a digital device, placed side-by-side, with synchronized content. Thumbing through the book's pages triggers the device to display the complementary digital content. The physical book requires no batteries or wires.
In the current version, the printed illustrations on each page of the physical book are extended into the device screen, offering further interaction.
The content can be explored both linearly by reading and thumbing the printed book and/or exploring the interaction on the digital device.
We also briefly explain the planned future study observation, with children, to evaluate our prototype.

Categories and Subject Descriptors
H5. 2. User Interfaces: Prototyping

General Terms
Performance, Design, Human Factors.

Keywords
Tangible interaction; children interaction; magnetic field sensor; touchscreen devices; e-books; e-picturebooks

1. INTRODUCTION
Over the years, electronic and digital possibilities combined with the traditional printed books, resulted in interesting experimental mixed-media books.

Both media usage can have advantages and disadvantages. As mentioned by Jürgen Steimle [1] “paper supports a wealth of interactions that have inherent advantages over the digital technologies”: both hands can interact with paper and “get tactile-kinesthetic feedback”; in a printed book we can sense “the appropriate number of remaining pages with one finger” [1].

IDC '13, Jun 24-27 2013, New York, NY, USA
ACM 978-1-4503-1918-8/13/06.

The picture books have an important place in the childhood as a mean of enjoyment and engagement with storytelling. Due to its intrinsic characteristics – format, dimensions, page space dominated by illustrations and small texts – it promotes also the children's shared book reading.

Digital media also has its advantages: it can include audio-visual and interactive digital media. The touchscreen introduced significant modifications on the digital media usage. The single user computer with "one mouse, one keyboard, and no touchscreen" [2] gave way to a multi-person input interface, so multiple users can gather around the display and interact with it [2].

With the Bridging Book prototype we are exploring concepts for children's mixed-media books that combine traditional picture book with touchscreen devices; we intend to engage children with a mixed-media book in a storytelling experience. Our main goal is "to preserve the aesthetic and emotional experience of reading a book while augmenting it with new technological capabilities"[3]. We seek “new and exciting opportunities for childhood activities” that technology does provide, as stated by Gelderblom & Kotze [4], without replacing valuable experiences such as handling books.

2. RELATED WORK
Even in the age of tablets and e-books, the printed book, in its multiple formats, is still an artefact of election for projects that explore the interaction that intersects the physical support with the digital medium, preserving the traditional book structure. Following this trend several mixed-media books such as augmented books, and books with embedded sensors and electronics, have been developed in the last 20 years.

We list here, chronologically, some of the most important mixed-media book references. Later, after our prototype's description, we will contrast these projects with our Bridging book approach.

The SIT (Sound-Image-Text) book (1999) [5] is a reading experience that combines the look and feel of a physical book with a movie soundtrack. The soundtrack is multi-track and includes music and sound effects. The SIT Book uses electric field sensors, located in the book binding, to sense the reader's book handling and the fingering of the page; these sensors control the ambient audio.

Listen Reader (2001) [6] is an electronically augmented paper-based book, with printed images and text. It provides an immersive reading environment: a comfortable chair, a polished hardwood reading stand, paper pages in a soft leather book binder and a sound system embedded in it. It has a multi-layered interactive soundtrack with music and sound effects that are triggered by the

user's action. It uses electric field sensor to sense the reader's hand proximity to control audio parameters, and embedded RFID tags to identify pages.

The magic book (2001) [7] in line with previous work proposes an augmented reality book where different media, including 2d, 3d graphics and animation, are integrated within the book pages and the surrounding space through an handheld device with screen and a camera recognizing visual markers.

Blink (2006) [8] is a technology that uses the physical book as interface. By pressing conductive ink printed buttons, the user may access different kinds of digital content, as his finger closes the printed circuit on the page. It communicates with nearby digital devices through a wireless module dissimulated in the book cover. The contents can vary depending on the type of application of this technology.

SequenceBook (2010) [9] is an interactive picture book. The physical book sits on a table, with a projector above and a speaker under the table. When the user starts flipping the book, the page is recognized, the background music starts and both images of the characters and texts are projected on the paper pages. The users can easily shuffle pages to make several patterns of stories, since the system is designed like a magnetic bookbinder. It consists of a paper book with thin IC tags embedded in each page and a Radio Frequency Identification (RFID) antenna.

Popables (2010) [10] is an interactive pop-up book that explores the paper-based computing and integrate traditional pop-up mechanisms with thin, flexible, paper-based electronics: it looks and functions much like an ordinary popup but has added elements of interactivity: sound, lights and mechanical movement.

Marginalia (2010) [11] is a book jacket system, with a fold out screen margin's extension, that explores the physical interactions with tangible print media. Based on the concept of historical marginalia, this project digitally extends the paper book by providing an interactive and networked digital margin space compatible with a stylus. The shared margins become a link between the physical textbook and its digital counterpart. Different contents and menus are available, allowing other users to communicate and interact with the same content or within specialized social networks, related to the book's content. The use of the pen/stylus allows interacting with the paper and the screen, as the user can write on both supports.

The book that turns its own page #2 (2010) [12] is a prototype of an interactive book that turns its own pages. The pages turn by themselves thanks to an electric signal sent through the binding. The material retracts when it receives electricity. The book connects to the Internet and can interact with a phone.

Elektrobiblioteka (2013) [13] is an interactive book that uses an hardback book as an interface. A physical book, with conductive ink printed circuits, enables the open book detection and connects to a computer via USB interface to control a dedicated website Each paper page has digital related content; the circuits detect the finger touch and activate additional animations, also integrated into the website.

Projects like the ones discussed above are generally received with enthusiasm and inspire other researchers to explore this line of research. They seldom though have an impact beyond the research community and the laboratories. High costs, too complex apparatuses, difficulty to envision practical applications are some of the reasons that can be pointed out.

In Bridging book, our approach was to base our development on off-the-shelf e-book reader devices, such as tablets, that are getting particular attention and popularity from children, parents and book publishers. Those platforms offer a more ready available hardware on top of which one can deploy and test mixed-media approaches. Also there is agreement that new media books offers exciting possibilities, but parents nevertheless typically see added value in traditional books [14]. Therefore, bridging new interactive e-book reader platforms with traditional reading experiences seems a good opportunity for investigation.

3. BRIDGING BOOK

3.1 Book Concept

The prototype consists of a physical printed book that controls a digital book, resulting in a combination between paper and digital artefacts. Our initial prototype and its corresponding content are framed for children aged between six and eight years old.

The contents are synchronized and interrelated between the printed book and the digital interface. The interaction takes place by both thumbing through the physical book pages, which makes the digital book pages flip in synchronization; and by touching the digital content on the tablet.

The narrative contents are: illustrations and animations; sounds and music; and short written texts. We propose the exploration of narrative's contents through the interaction on both media. The feedback is contextual and it consists of animations, sounds and music.

3.2 Technical development

The Bridging Book combines a physical book containing magnets with a touchscreen tablet that incorporates a built-in digital compass. The synchronization between the thumbing of the physical book and the digital content is achieved by placing magnets on the book pages that change the magnetic field strength detected by the digital compass sensor (see figures 1 and 3).

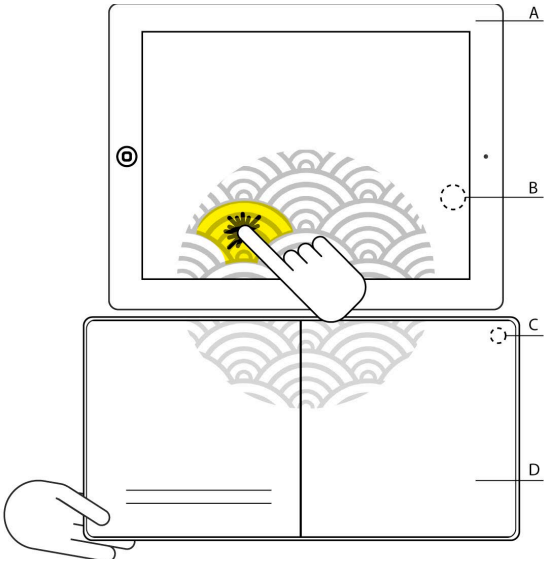

Figure 1. A - Tablet device; B - Approximate compass sensor location; C - Hidden magnet; D - Physical paper book.

In the current implementation we used an iPad 3rd generation tablet with iOS 5.1, although it is possible to implement it in any tablet device that has a digital compass sensor.

The first approach was: to analyze the measures' magnitude of each axis (X, Y and Z-axis); and to evaluate the total magnitude detected when the book, with incorporated magnets, was manipulated next to the device (see figure 2).

These tests revealed that the sensor's Z-axis readings provided enough information to track the page flipping of the physical book (see figure 2).

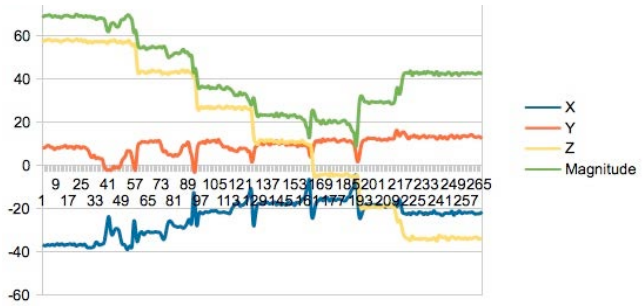

Figure 2. Magnitude measurements — axes X, Y and Z.

The magnets location on the page should be such that it allows the magnets to move ideally from the closest distance to the device compass sensor, to the furthest place away from the sensor, to unleash the maximum variation on the magnetic field, when flipping the pages (see figures 1 and 3).

Different magnet sizes and distinct locations were tested with several book layouts, to verify which was the most adequate for the detection needs and to improve the user experience.

From that analysis we selected the final setup of this prototype (see figures 1, 3 and 4): the iPad is oriented in landscape mode (turning it to the right) and the book is placed aligned to the lower bottom right of the device in a way that the sensor is closer to the book; each page has an incorporated magnet. The approximate location of the iPad magnetic sensor and the magnets location on the book can be seen in figures 1 and 3. The choice of this layout is related to the optimization of the interaction between the digital and the paper interfaces.

The first book built has seven cardboard pages (130mm*130mm, 1mm thickness). Each page, including the cover, has at the top-right corner, an incorporated disc magnet (nickel-plated), 6mm diameter and 1mm height (see figures 1 and 3). The magnets have an axial magnetization direction (parallel to the height) with the approximate strength of 350g.

The software detects the opened page by reading the strength of the magnetic field from the compass sensor. The strength of the magnetic field is induced by the presence of magnets on the pages. Since each page has a magnet with a known magnetic force, when a page is flipped, the new cumulative sensor's reading will be decoded as a page number.

The software was developed on ActionScript 3.0, compiled on Air 3.0, using Adobe Flash Builder. As this solution doesn't allow the direct access to the device's sensors data, we used an Air Native Extension, developed by distriqt [15], to communicate with the digital compass.

Since the exact values of the sensor compass' readings may vary,

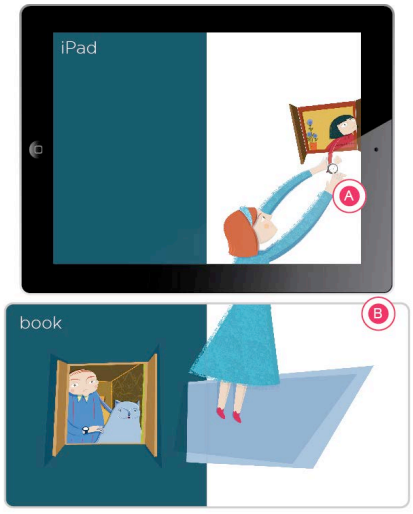

Figure 3. iPad and book with magnets. A - Approximate compass sensor location; B - Approximate location of hidden magnet.

depending on the environment and the distance from the book to the device, the software application performs initially a calibration process, which consists in a baseline reading of the magnetic field's magnitude with the book closed. From that baseline reading, the software estimates the book distance and the changes on the magnitude of the magnetic field, based on the previous tabular readings.

To assure a robust page tracking, after the initial calibration the book should not move significantly relatively to the device. Designing the book so that it attaches mechanically to the device would be a way to ensure that children keep it within the same distance during its use. Also, some devices may implement a digital compass sensor interference detection and recalibration routines. Occasionally that feature interferes with our approach. In those cases we would need to turn that feature off on the device, if possible, or request the user intervention.

Figure 4. Bridging book

3.3 Bridging book use

The open book follows the entire horizontal side of the tablet screen (see figures 1, 3 and 4); this spatial relation between magnetometer and book magnets improves the differences between magnetic readings (see figure 2).

Each page of the physical book has a corresponding digital set, which includes short animations and interactive elements, context and feedback sounds. The illustrated content has been divided between the paper and the screen. The digital visual content of each page has interactions and context's sounds synchronized to the current printed page (see figure 4).

3.4 Bridging book and other approaches

Comparing our prototype with the projects presented earlier we find some advantages in our approach: since we are using magnets we do not require any electronic active components and therefore batteries or connection with the device; the magnets cost is low; and opposed to the computer vision techniques they do not suffer from occlusion problems. The widespread of tablets' usage is another aspect that also promotes the interaction based on magnets.

These characteristics allow us to glimpse several applications to the Bridging book prototype.

4. FUTURE DEVELOPMENT

User evaluation will be our project next step: we are currently planning studies to evaluate how children interact with the Bridging book.

The main goals of this study are:

1. Realize how children do understand and use our prototype;
2. Observe unexpected ways of usage and/or unpredicted interactions that can emerge;
3. To envision possibilities for the prototype's improvement.

This evaluation study will have various stages and we will evaluate the prototype with children aged 7 to 8 years old.

Since the children involved can have different backgrounds, concerning the use of digital media and books, and this personal experience can have a meaningful impact on the study, we will do a set of questions asking about their experience with books and digital media to understand better their engagement on the evaluation.

After, we will compare the usage of our prototype with the reading and handling of a digital version of it. On our study we think that can be helpful to parallel these different kinds of books to uncover eventual issues related to the prototype usage and to evaluate the engagement with storytelling, in both books.

In each session we will have two groups with two or three children each. One group will be with the Bridging book prototype and the other with the digital version of it. Halfway into the session time the groups will exchange place between each other.

Finally we will conclude the sessions with in-group talks to hear about the children experience.

In the future we plan to develop this prototype, incorporating on it what we learn in the study with the children.

To seek possibilities to future mixed-media books and to narrative models are project pathways already planned.

5. ACKNOWLEDGEMENTS

This work is funded by FEDER through the Operational Competitiveness Factors Program - COMPETE and by National Funds through the FCT – Portuguese Foundation for the Science and the Technology within the Projects: PTDC/CCI-COM/119030/2010, FCOMP-01-0124-FEDER-022674 and the Doctoral Grant: SFRH/BD/80512/2011

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