SequenceBook: Interactive Paper Book Capable of Changing the Storylines by Shuffling Pages

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Abstract
In this paper, the author proposes *SequenceBook*, an interactive picture book system, which consists of a paper book with very thin IC tags embedded in each page and an RFID antenna. This system uses a traditional paper book as an interface and realizes natural interface that keeps the affordance of traditional book and thus smoothly prompts users to experience its contents by just flipping pages in the same way as they read an ordinary book. Another important feature of the system is that users can change its storyline as they like. The system is designed just as like a bookbinder so that users can easily shuffle pages and make several patterns of stories.

Keywords
RFID, HCI, Tangible User Interface, Media Art, Picture Book, Story Creation

ACM Classification Keywords
H5.2. User Interfaces

General Terms
Design

Introduction

Since early times, picture story book has been important tool for children and also enjoyed as entertainment by adults.

Many years later, as computer progresses, people are getting interested in making books highly computer-supported. As a result, some digital storytelling contents on computers, such as e-novels, have been created and spread into our daily life. However, while it allows users to enjoy rich multimodal contents that traditional paper book do not have, paper book have not faded from our daily life. The author thinks that this is because of naturalness and familiarity as an interface of paper book.

Based on the facts that traditional paper books have been widely used until now, the author aims to develop novel paper book which users can enjoy rich multimodal contents like software on computers while keeping the affordance of traditional book.

In this paper, the author proposes *SequenceBook*, which uses a traditional paper book as an interface to experience digital contents, so that it can keep the affordances of paper books while adding electronic augmentation. The aim of this study is to achieve both highly computer-supported contents and natural interface, e.g., highly efficient combination of physical and digital world. With *SequenceBook*, every person (especially who is not good at operating computers) can enjoy rich digital contents just by flipping pages.

In this study, the author also aims to develop an efficient and novel system to encourage creativity and activeness of users in reading. To achieve this purpose, it is very important for users to make sequences of a story by their own hand. Therefore *SequenceBook* was constructed like a bookbinder so that users can easily change a sequence of pages and enjoy several patterns of stories.

Related Works

Some researchers have been interested in visually augmented books. Augmentation of book by using Mixed Reality Technology has been also accomplished by previous works, e.g. *The Mixed Reality Book* [3] and *The Magic Book* [5] are representative examples. *Interactive textbook and interactive Venn diagram* [6] attempted to project information next to the book. *Listen Reader* [4] is a system using IC tags embedded in each page like *SequenceBook*.

From a standpoint of story creation, some systems have been developed. *StoryMat* [7] is a physical play mat that records voices of storytelling play and the movements of the toys. *The Lost Cosmonaut* [8] is the system for narrative creation using paper as an interface. *StoryBuilder* [1] is an online storytelling system that allows users to add to stories by others in a comic-book style.

While systems like *StoryMat* is efficient for story creation, the author thinks that a form of traditional book has potential to prompt users to enter a world of the story rather than other forms because many stories have been recorded and read in a book form traditionally until now.

In addition, one of the biggest progress of this work is that user can change the storyline by shuffling pages that has not been accomplished in related works using a book form.

In *the Mixed Reality Book* or *The Magic Book,* users need to put some equipments on themselves in advance, whereas, *SequenceBook* does not require any equipment on users that is not usual in reading, while some physical limitations, such as positionally-fixed book or requirement of setting up devices to a table are remaining. Its "just flip and read" interface is traditional and amiable, so it may prompt users to understand the story like they read an ordinary book.

System Architecture

Overview of *SequenceBook* system is as follows: The user can see one book on a table in front of him. A projector is set above the table to project movie onto the pages of the book and a speaker is set under the table to play background music. The RFID (Radio Frequency IDentification) antenna is installed under the table. When the user starts to flip the pages, the RFID antenna recognizes which page the user is actually looking at. And at the same time, background music starts to play and the projector starts to project both images of characters and narrative texts (figure 1).

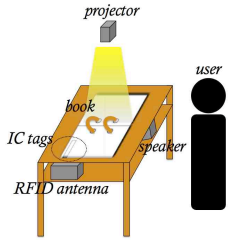

figure 1. Overview of *SequenceBook* system.

Page Identification

For page identification, the author selected RFID as an efficient method to identify individual pages because image processing, the most general technique for identification, is easily affected by light condition and human hands and not suitable for this case. However, IC (Integrated Circuit) tag used in previous studies is too big and thick to be naturally embedded in a page. So previous works using RFID have a problem of unnaturalness as a book.

To overcome this problem, *SequenceBook* uses μ-chip (Hitachi, Ltd.), very small and thin (51.5mm height, 1.5mm width, 0.25mm thickness) passive IC tags for this system (Figure 2). By sandwiching them between papers (charcoal paper, 0.19mm thickness) of pages, IC tags become invisible and not touchable for users while pages keep their thinness and naturalness of ordinary papers. So users can flip pages easily like a paper book without IC tags. And they can also easily shuffle pages.

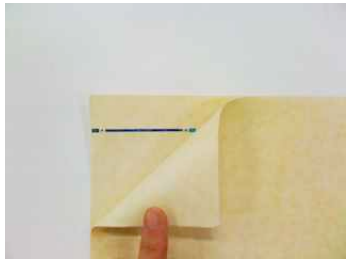

figure 2. Embedded IC tag (μ-chip) in a page.

To detect embedded IC tags, the RFID antenna is installed under the table. The thickness of the table is enough thin so that it does not miss detection of tabletop IC tags. To enable the RFID antenna to work perfectly,

the book with IC tags is put on designated location on the table. The RFID antenna can detect more than one tag simultaneously by its anti-collision technology. The author confirmed that the recognition rate was 99.3% in experiment. When users turn a page, the RFID antenna recognizes it as the change of the IC tags within its read range (about 40 mm).

Page Binding and Shuffling Mechanism
To keep the IC tags within the detectable area of the RFID antenna, the book is fixed using a magnetic binder. All pages are put together using two rings with magnets and fixed to certain position of the table (Figure 3).

With the magnetic binder, users easily fix and unfix all pages to shuffle them. This is one of the most important technical innovations of *SequenceBook*, that is, shuffling pages as users like and change the storylines. To develop this page-shuffling system, realizing manageability of pages by using very thin IC tags is essential.

While some previous works, such as *StoryBuilder*, allow users to customize existing narrative pieces (setting or characters), *SequenceBook* system allows users only recombination of pages. The reason is that story creation by simply shuffling pages does not require any electronic equipment and does not interfere with natural interaction with paper books.

Process of creating storylines by shuffling pages goes as follows: Once you take off all pages from the binder, you can see background images drown directly onto each page. Next, just shuffle pages to make different raw of sequences of a story. When you put back all pages to the binder in a different order, the RFID antenna detects rearranged IC tags and corresponding images are projected and new background music starts to play.

The number of pages should be considered for designing the page-shuffling system. The more pages are added to the book, the more possible stories will be created. This means too many number of pages make storyline complicated and as a result, it will be impossible to arrange consistent stories in advance. So the author made the book with four pages, which gives story branches 24. This number does not seem to be too few to create enjoyable stories.

Sequence Visualization
The RFID antenna and reader send information of IC tags to the PC and reconciled data with the hash table to translate it to page IDs (from A to D) after buffering for a given length of time. Then one of stories arranged in advance is called up from detected page IDs and movie and background music starts to play.

figure 3. Woody book covers, paper pages, and woody rings with magnets to bind pages and projected images onto pages.

Connection of Sequences

Contents

To shuffle pages and create their own stories easier, some kind of visual clues have to be assigned to all pages in advance. As a hint to change row of pages, the background of each scene is drawn to every page directly by palette.

Skipping and going back in reading

The system also allows users to skip pages and go back to any page. For example, if user flipped two pages (page B and C) at one time from page A, the system choices randomly one storyline from possible two patterns (A-B-C and A-C-B) and project suitable sequence of storyline. And the system enables users to re-create storylines even at the middle of storylines. For example, after reading the storyline B-C-D-A, the user can go back to page C, and shuffle remaining two pages (page D and A) and restart reading from page D and enjoy another storyline (B-C-A-D). In this way, users can seek favorite storyline by shuffling pages again and again.

Experiment and the Results

The author conducted a demonstration experiment of the system in the annual exhibition of technology and art in *University of Tokyo*. 240 people experienced the system during exhibition. The author stayed beside the system to answer the question from users and count the number of shuffling pages. The author analyzed of the result based on following two points, which characterize the system.

Naturalness of the paper book interface

129 of all 240 people asked the author about the mechanism of page detection. Only 5 people (about 4 percent of people interested in page detection technique) guessed that something is embedded in a page while most people had no idea or guessed that image processing is used (figure 4). The result indicates that most people didn't notice the presence of detection system inside of the thin papers, suggesting that this system keeps enough naturalness of papers even after sandwiching IC tags.

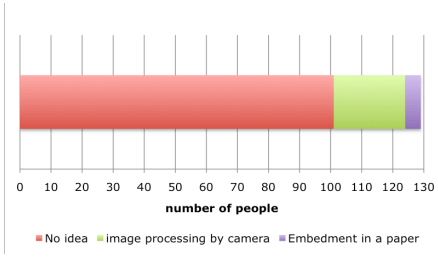

figure 4. Guess how the system detects individual pages.

Availability of page-shuffling system

How many times people played with shuffling will tell how people can enjoy this system. The author put the description about story change mechanism by shuffling pages, so almost all people tried to shuffle pages at least once. 225 people (about 94 percent of people) shuffled pages more than once (figure 5). The reason why people played with this over and over are as follows; Some said it is just a fun to play with. Others said they tried to find the mechanism of change of storylines by shuffling pages. This result indicates that the page-shuffling system provides enjoyment to people at some level. Although further experiments are needed to validate the utility of the page-shuffling system.

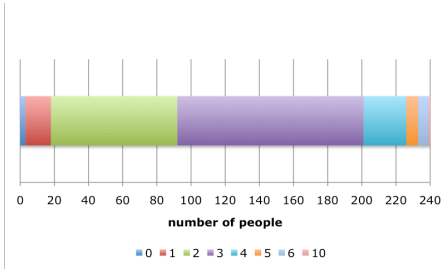

figure 5. How many times people played with the shuffling system.

Conclusion

The aim of this study is to add digital contents to traditional paper books. To achieve the goal, the author embedded very thin IC tags in a paper of each page. From the demonstration experiments, the naturalness of the proposed page detection system has been verified. This study also proposed a page shuffling as a novel form of technique of story creation. Through the demonstration experiments, the mechanism has entertained people and showed the possibility of novel form of story creation tool.

Future Work

SequenceBook will be further improved by increasing the possible number of storylines by simply increasing the number of pages. However it is impossible to arrange storylines in advance with SequenceBook which has over 100 pages. So an efficient algorithm to make storylines automatically will be needed. This may be challenging problem in the field of artificial intelligence.

Secondly, if users can change not only the raw of sequences, but also appearance of characters, settings or narratives, it will also improve *SequenceBook*. For example, development of image processing system to change appearance of characters at certain scenes by dragging in characters from outside of the book and dragging out them to the outside with a finger seems to be effective. This allows imagination of users to wander in any direction of the story.

Example Citations

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