Development of a Semiautomatic Production System for Efficient Production of Multimodal Textbooks.

Takuya Takaira[1], Yoshiaki Tani[2], and Akio Fujiyoshi[3]

[1] Graduate School of Science and Engineering, Ibaraki University
15mn716f@vc.ibaraki.ac.jp
[2] Graduate School of Science and Engineering, Ibaraki University
15nm720l@vc.ibaraki.ac.jp
[3] Faculty of Engineering, Ibaraki University
akio.fujiyoshi.cs@vc.ibaraki.ac.jp

Abstract

In this paper, we will introduce a semiautomatic production system for the efficient production of multimodal textbooks. Multimodal textbooks are paper-based textbooks with audio support for students with print disabilities. Since invisible 2-dimensional codes are printed overlappingly on the normal characters of regular textbooks, if a 2-dimensional code is scanned by a digital audio player with a 2-dimensional code scanner, corresponding speech sound is reproduced. The semiautomatic production system analyze the layout of PDF file and enable us to assign sound files with drag and drop operations. Multimodal textbooks can be produced in a much shorter period with higher quality.

1 Introduction

Multimodal textbooks [1, 2] are paper-based textbooks with audio support for student with print disabilities. Since invisible 2-dimensional codes are printed overlappingly on the normal characters of regular textbooks, if a 2-dimensional code is scanned by a digital audio player with a 2-dimensional code scanner, corresponding speech sound is reproduced. They have already been used in some elementary schools and junior high schools in Japan.

Currently, the elementary school textbooks in Japanese language published by Mitsumura Tosho publishing Co.,Ltd and Tokyo Shoseki Co.,Ltd (covering 85% of market share) are available as multimodal textbooks. The junior high school textbooks in Japanese language published by Mitsumura Tosho publishing Co.,Ltd (covering 64% of market share) are also available. However, we have received a lot of requests from users to produce multimodal textbooks in other study subjects such as social studies, science and mathematics.

A semiautomatic production system is developed to ease the production Process of multimodal textbooks. Before the development of the system, the production of multimodal textbooks was very difficult. The arrangement of 2-dimensional codes on documents was done manually with graphic editor software, and the assignment of sound files to 2-dimensional codes needs manual renaming of sound files. From a PDF file of a textbook, the semiautomatic production system automatically analyze the layout of the textbook and arrange 2-dimensional codes on each page of the textbook. Sound files can be assigned to 2-dimensional codes with drag and drop operations. The result of layout analysis can be corrected by an editor of the system. The assignment of the sound files can be checked without printing out. The time needed to create multimodal textbooks is much reduced.

The semiautomatic production system is designed so that we can create multimodal textbooks without special skills. For the evaluation, we checked if the system could be used by university students with a brief introduction. We plans to release the system to the public in near future so that member of volunteer groups can produce multimodal textbooks.

2 Multimodal Textbook

Utilizing inviable 2-dimentinal codes and digital audio players with a 2-dimensional code scanner, multimodal textbook textbooks was developed (Figure 1). The textbooks can be read with the combination of the two mode: "reading printed text" and "listening to the speech of the text from a digital audio player with a 2-demensional code scanner." Since sight and hearing help each other, we can read them easily and correctly.

Figure 1: Multimodal Textbook and Scanner of 2-Dimension Code

2.1 Features of Multimodal Textbooks

Multimodal textbooks can be easily used in ordinary classrooms because the look of multimodal textbooks is almost the same as regular textbooks. The layout and the page numbering are completely the same. Users can write memo on the textbooks with pencil or a fluorescent marker without any trouble.

The price of the digital audio player is reasonable (about 4000 yen). It has been confirmed that the digital audio players with a 2-dimensional code scanner are usable by preschool children and intellectually disabled children.

3 Semiautomatic Production System

In order to ease the production process of multimodal textbooks, a semiautomatic production system for multimodal textbooks developed (Figure 2).
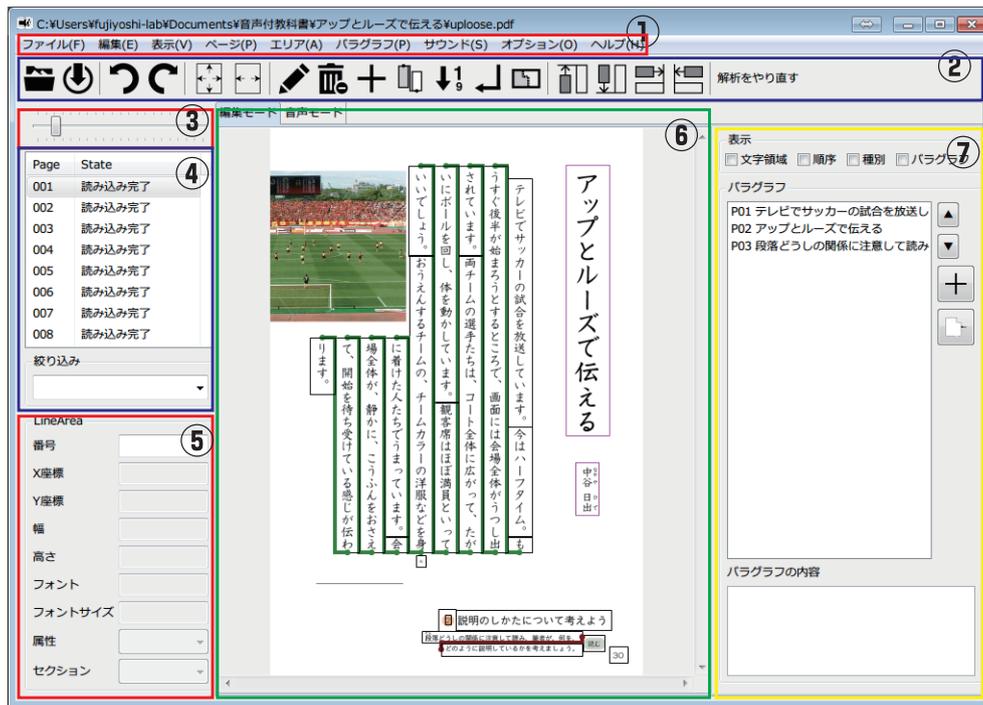

Figure 2: Semiautomatic Production System

3.1 Specification of the System

The System is developed on Java with standard widget toolkit (SWT). Pdfminer [3] and Ghostscript [4] are used in the system. Pdfminer is used to obtain character information from PDF files. Ghostscript is used to make image files from PDF.

Since the system is developed on Java, it runs on multi-platforms: Windows and OS X. The table 1 shows the system requirements.

Operating System	Windows 7 or later OS X 10.9 or later
Display Resolution	XGA 1024×768 (Full HD 1900×1080 recommended)

Table 1: System Requirements

3.2 Automatic Layout Analysis

The semiautomatic system automatically analyze the layout of a PDF file. The analysis is done in the following steps:

1. The system calls pdfminer to obtain character information from a PDF files. The information of font name, fontsize, position, size of bounding-box and order of characters are used.

2. A sequences of characters with the same font name and the same font size are combined if they don't contain a full stop character at the middle. The combined charters form an area called "line." Full stop characters are chosen from '.', ':', ';' and ','.

3. A class is automatically assigned to each line. A class is chosen from "HEAD", "BODY", "NOTE", "LIST" and "AUXILIARY" by font size and position in a page.

4. A sequences of lines in the same class are combined if an indentation dose not exsist between lines. They form a reading units.

3.3 Design of the Editor

The system has following features:

- Major functions can be accessed by pushing icons on the toolbar (area 2 of Figure 2).

- On the center, the image of a page in the PDF file is shown (area 6 of Figure 2). Scale can be adjusted by the scalebar (area 3 of Figure 2). Pages can be selected from the list (area 4 of Figure 2).

- Lines in a page can be edited. We can combine and remove lines. Creation of a new line and resize of a line can be done with a mouse operation (Figure 3)
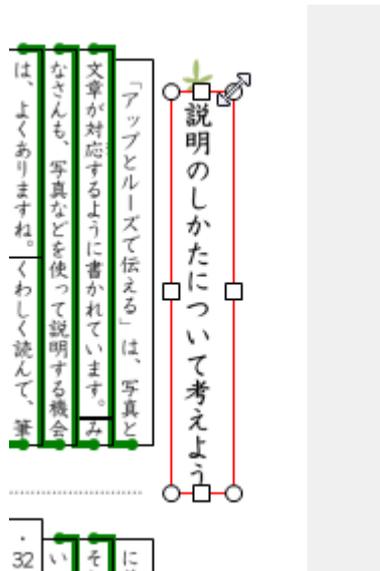

Figure 3: Resize of a line with a mouse operation

- Sound files can be assigned to each line with drag and drop operations. Sound formats, wave and mp3 are supported. Sound files is combined automatically when more than 2 sound files are assigned to the same line. The assignment of the sound files can be checked on the system without printing out.

3.4 Creating Multimodal Textbooks with the System

Multimodal textbooks are created by the following directions.

1. Choose an input PDF file.

2. The system automatically analyze the layout of the PDF file. The results of analysis are lines, classes of lines and paragraphs. They are display on the center of the window.

3. Errors of the automatic analysis can be corrected by users with the editor of the system. It is easy because of the simple interface of the editor.

4. The system outputs data of 2-dimensional codes and a manuscript for reading the document. Using the data of 2-dimensional code, multimodal textbooks can be printed. The manuscript for reading the document will be Transferred to volunteers.

5. Assign sound files to lines by drug and drop operations. The system can play the assigned sound files.

3.5 Creating Printing Data for Mass Production

For mass-production at a printing office, we need to create printing data. First, we convert the color of PDF data of a regular textbook so that black color will not be used to print characters and pictures. The converted PDF data consists of only cyan, magenta and yellow colors. As shown figure 4, the printing data is obtained by placing black dot patterns of 2-dimensional codes upon the color converted PDF data of a regular textbook.

Color-converted PDF data of a regular textbook in CMY color + Dot patterns of 2D codes in black color = Print Data for a multimodal textbook
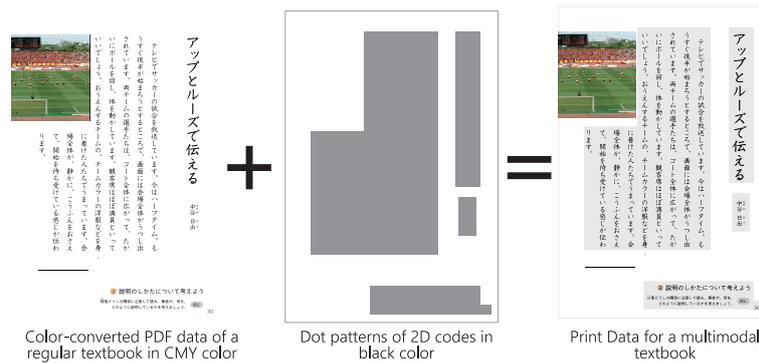
Figure 4: Making the print data

The printing data is also in PDF format, which can be used not only for mass production at a printing office but also for individual production with some laser printers (with resolution more than 600 dpi and avoidable from CMYK color conversion).

4 Experiment of Evaluation

Since the semiautomatic production system for multimodal textbooks was developed, the cost of production of print data and sound data was much reduced. In addition, the number of mistakes was much decreased.

Before the development of the semiautomatic production system, the production of dot patterns of 2-dimensional codes was done with Garyotensei(Apollo Japan Co.,Ltd). Garyotensei is an image editing software for 2-dimensional code patterns. Its usages is like a bitmap editor such as Microsoft Paint, which is used with mouse operations.

In order to evaluate the semiautomatic production system, we compare the time needed to produce dot patters of 2-dimensional codes for a collection of pages from textbooks with our system to the time needed with Garyotensei. The collection consists of 6 pages, story, expository writing, work, Kanji table, discussion and essay form textbooks in Japanese language for elementary school published by Mitsumura Tosho publishing Co.,Ltd. Figure 5 shows the collection of 6 pages. The number of pages, characters and reading units of the collections of pages are shown in Table 2.

The Number of Pages	The Number of Characters	The Number of Reading Units
6	2108	177

Table 2: The Number of Pages, Characters, Reading Units

For experimental subjects, 3 university students are employed. They are asked to create dot patters of collection of the pages by the different the ways. The one way is using Garyotensei and the other way is using the semiautomatic system.

Time needed with semiautomatic system is about 40% less than with Garyotensei. The result is shown in Table 3

Subject	Garyotensei	Semiautomatic System
Subject A	22min45s	7min55s
Subject B	31min55s	10min30s
Subject C	24min10s	9min41s

Table 3: The Result of Experiment

5 Cost of making multimodal textbooks.

Table 4 shows the time needed to produce dot patterns of 2-dimensional codes of some textbooks. Dot patterns of each textbook were produced by a different university student. The time needed to produce the sound data was about 12 hours for 3rd or 4th grade and 20 hours for 5th or 6th grade. The assignment of sound files ca be done in similar time (from 15 hours to 25 hours).

We can say that the cost of making multimodal textbooks is not so high.

Figure 5: The Collection Of Pages from Textbooks (Published by Mitsumura Tosho Publishing Co.,Ltd)

Title	Pages	Time
Japanese language for 3rd grade (book one) by Mitsumura Tosho	144	12hours 15min
Japanese language for 4rd grade (book one) by Mitsumura Tosho	150	11hours 45min
Japanese language for 5th grade by Mitsumura Tosho	284	18hours 45min
Japanese language for 6th grade by Mitsumura Tosho	284	19hours 30min

Table 4: Time Needed to Produce Dot Patterns of 2-dimensional Codes of Textbooks

6 Conclusion

The semiautomatic production system was developed for efficient production of multimodal textbooks . According to the results of time needed to produce dot patterns of 2-dimensional codes, the system enable us to create multimodal textbooks much shorter period. In addition, we should mention that the number of mistakes was much reduced the quality of the multimodal

textbooks was much improved.

We plans to release the system to the public in near future so that member of volunteer groups can produce multimodal textbooks.

Acknowledgement

References

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[2] Fujiyoshi, A., Ohsawa, A., Takaira, T., Tani, Y., Fujiyoshi, M., and Ota, Y.: Paper-Based Textbooks with Audio Support for Print-Disabled Students, the proceedings of AAATE (2015) 11-18.

[3] pdfminer, `http://www.unixuser.org/~euske/python/pdfminer/`

[4] Ghostscript, `http://www.ghostscript.com/`