

Development of Multimodal Textbooks with Invisible 2-Dimensional Codes for Students with Print Disabilities

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Abstract. Utilizing invisible 2-dimensional codes and digital audio players with a 2-dimensional code scanner, we developed a new type of textbooks for students with print disabilities, called “multimodal textbooks.” Multimodal textbooks can be read with the combination of the two modes: “reading printed text” and “listening to the speech of the text from a digital audio player with a 2-dimensional code scanner.” Since a multimodal textbook looks the same as a regular textbook and the price of a digital audio player is reasonable (about 30 euro), we think multimodal textbooks are suitable for students with print disabilities in ordinary classrooms.

1 Introduction

In 2012, Japanese Ministry of Education, Culture, Sports, Science and Technology published a report about students with developmental disorder in ordinary classrooms in compulsory education. According to the report, 2.4% of students in ordinary classrooms have remarkable difficulties in reading or writing without intellectual retardation. This means that most students with print disabilities are in ordinary classrooms and they use regular textbooks.

Utilizing invisible 2-dimensional codes and digital audio players with a 2-dimensional code scanner, we developed a new type of textbooks for students with print disabilities (Fig. 1). We can read these new textbooks with the combination of the two modes: “reading printed text” and “listening to the speech of the text from a digital audio player with a 2-dimensional code scanner.” So we call them “multimodal textbooks.” Since sight and hearing help each other, we can read them easily and correctly. Authors have developed auditory testing media for test-takers with print disabilities [1, 2, 3]. To create multimodal textbooks, we took advantage of the experience and technique gained during the development of auditory testing media.

For students with print disabilities, large print textbooks and DAISY textbooks have been available in Japan. Recently, textbook publishing companies



Fig. 1. Multimodal Textbooks

started producing large print textbooks by themselves at their expense. The quality of large print textbooks is very improved. DAISY (Digital Audio Accessible Information System) is a world standard of accessible books for people with print disabilities [4]. A number of textbooks are translated into DAISY by the efforts of volunteers. Many students with print disabilities in special supported classrooms use either large print textbooks or DAISY textbooks. However, the number of students in ordinary classrooms who use these textbooks is very few.

A multimodal textbook consists only of a paper textbook and a digital audio player with a 2-dimensional code scanner. Since the paper textbook looks the same as a regular textbook and the digital audio player is small and can be used with a headphone, multimodal textbooks can be easily used in ordinary classrooms. Multimodal textbooks have the following other features:

- They are easy to carry.
- The price of a digital audio player is reasonable (about 30 euro).
- Students can write memo on the paper textbooks with a pencil or a fluorescent marker.
- Students can study by themselves.
- Teachers can easily get to know positions where students are reading.

In 2011, the first trial version of multimodal textbooks was made. With the trial version, multimodal textbooks were demonstrated to teachers, researchers and editors of textbooks. From October 2012, a practical evaluation started with 8 elementary school students with print disabilities in Shinagawa, Tokyo. From April 2013, the practical evaluation was continued with 30 elementary school students in Shinagawa, Tokyo.

A semiautomatic production system for multimodal textbooks was developed in order to ease the production process of multimodal textbooks. From a PDF file of a textbook, the semiautomatic production system automatically recognize the layout of the textbook, arrange 2-dimensional code on each page of the textbook

and produce a manuscript of the speech of the text. The system also has an editor for corrections.

Currently, all 10 titles of elementary school textbooks in Japanese language published by Mitsumura Tosho Publishing Co.,Ltd., all 3 titles of junior high school textbooks in Japanese language published by Mitsumura Tosho Publishing Co.,Ltd., all 12 titles of elementary school textbooks in Japanese language published by GAKKO TOSHO Co.,Ltd, and 2 titles of junior high school textbooks in English language published by SANSEIDO Co.,Ltd. are available as multimodal textbooks.

2 Development of Multimodal Textbook

2.1 Invisible 2-Dimensional Codes and a Digital Audio Player

The introduction of invisible 2-dimensional codes and digital audio players with a 2-dimensional code scanner enable us to develop multimodal textbooks.

We employ ‘screen code’, an invisible 2-dimensional code system developed by Apollo Japan Co., Ltd. Screen code consists of dots in 2 mm square (Fig. 2). Since the intervals are large enough for the size of dots themselves, dots are almost invisible. If we use invisible ink, which absorbs only infrared light, instead of black ink, dots become totally invisible.

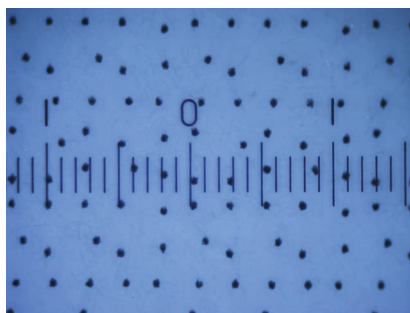


Fig. 2. Dots of ‘screen code’

As a reading device for multimodal textbooks, we employ ‘Speakun’ developed by Apollo Japan Co., Ltd (Fig. 3). Speakun has a 2-dimensional code scanner at its top. When a 2-dimensional code is scanned with Speakun, the corresponding speech sound is reproduced. We can listen to the sound through a headphone or built-in speaker. The sound volume and speed can be adjusted with its buttons mounted at the front side. The sound data is stored in a micro SD card. 2G byte is enough to store all sound data of all textbooks of a student.



Fig. 3. Speakun

2.2 Semiautomatic Production System for Multimodal Textbooks

Currently, multimodal textbooks are produced by a small number of staffs. In order to ease the production process of multimodal textbooks, a semiautomatic production system for multimodal textbooks was developed (Fig. 4). The system is written in Java, and takes advantage of software packages Ghostscript [5] and PDFMiner [6]. From a PDF file of a textbook, the semiautomatic production system automatically recognize the layout of the textbook, arrange 2-dimensional code on each page of the textbook and produce a manuscript of speech sound. The system also has an editor for corrections.

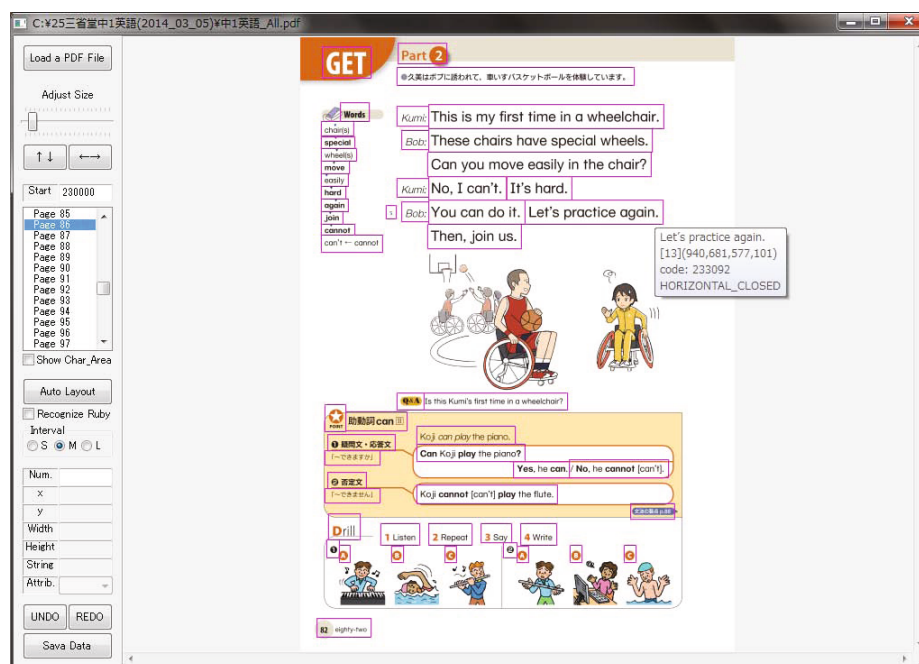


Fig. 4. Semiautomatic production system for multimodal textbooks

The assignment of speech sound files to 2-dimensional codes can also be done with the system. A sound file can be assigned to a set of rectangular areas to print the same 2-dimensional code by a drag-and-drop operation.

With this system, arranging 2-dimensional code on a textbook of 300 pages can be done in 20 hours by a person, which is 5 times faster than without the system. 27 titles of multimodal textbooks have been made so far.

3 Design of Multimodal Textbooks

Multimodal textbooks were designed so that they help to improve users' ability of reading. Thus the "reading printed text" mode should take precedence over the "listening to the speech of the text" mode. In other words, while users are listening to speech sound, we want them to read the corresponding printed text by their sight. Therefore, we put a different 2-dimensional code to each sentences and cut speech sound files into small pieces so that only corresponding speech sound is reproduced by one scan.

Fig. 5 shows a page of a multimodal textbook in English language for junior high schools (New Crown 1, SANSEIDO Co.,Ltd.). Every rectangle is assigned to a different 2-dimensional code except rectangles connected by brown lines. A set of rectangles connected by brown lines is assigned to the same 2-dimensional code.

Users have to scan a 2-dimensional code every time they want to read the next sentence. In order to scan the 2-dimensional code of the next sentence smoothly, users have to trace printed characters of the current sentence.

4 Results of a Preliminary Investigation on Multimodal Textbooks

In August 2013, we made a preliminary investigation in order to check how multimodal textbooks had been used in class and at home. We delivered questionnaires to the users of multimodal textbooks in a practical evaluation in Shinagawa, Tokyo. Since the most users are elementary school students, the questionnaires were entered by a parent or a teacher of them. We have received 15 answered questionnaires from the users of multimodal textbooks. They were from 8 elementary school students in lower grade, 6 elementary school students in higher grades, and 1 junior high school student. The percentage of reply for the questionnaires was 50%. The results are as follows:

4.1 Usage of Multimodal Textbooks

Among the 15 users, 13 persons (87%) mostly use multimodal textbooks at home for preparation and review. Only 2 persons regularly use multimodal textbooks in class.

USE **Read**

● 車いすバスケットボールを見学した久美のレポートです。どのようなスポーツなのか、確認しよう。

Pre-Reading
バスケットボールについて知っていることを話し合おう。

Words
people
Japan
shoot

Wheelchair Basketball

□ Do you know about wheelchair basketball?
Many people play it in Japan.

② This is Mr Kyoya Kazuyuki. He plays basketball. He is in a special wheelchair. He can move easily in it. He is a very good player. He can shoot very well.

京谷和幸選手

Tip
車いすバスケットボールのルールは、車いすでプレイするために改めたところ以外は、コートの高さ、ゴールの高さ、ボールの大きさなど、すべて一般のバスケットボールと同じ。1チーム5人。1ゲームは10分を4回。

In-Reading

1 本文を一度読んで、印象に残った語句を書き出そう。

2 もう一度読んで、次の問いに答えよう。(□の数字は段落を示しています。)

① What sport does Mr Kyoya play? (□)

② What can Mr Kyoya do very well? (□)

③ Can players push their chairs with the ball many times? (□)

3 車いすバスケットボールのルールを英語で言ってみよう。

Check
① 2行めの#は符を指しているでしょう。
② 5行めの#は符を指しているでしょう。

84 eighty-four

Fig. 5. A page of a multimodal textbook in English language for junior high schools (New Crown 1, SANSEIDO Co.,Ltd.)

4.2 Impressions from Students

The following impressions were received from students: “It is convenient to read because Chinese characters (kanji) are read by the machine.” “It is easy to study intonation and punctuation of a sentence.” “I can freely choose a sentence to read.” “Because of sound, a lot of sentences can be read.” “The speech speed control is convenient.” and “It is good because we can write the reading of a Chinese character in kana at its side.”

The following requests were also received from students: “Please make any other books be like multimodal textbooks.” and “I want to take tests with sound.” We think they are our big future works.

4.3 Impressions from Parents and Teachers

The following impressions were received from parents and teachers: “A multimodal textbook is easy to use. My child can use it by himself.” “My child can study at her own pace with a multimodal textbook.” “Children are very interested in mechanism of digital audio players with a 2-dimensional code scanner.” and “A multimodal textbook is a pleasant tool since students can use it by themselves for preparation and review.”

5 Conclusion

Utilizing invisible 2-dimensional codes and digital audio players with a 2-dimensional code scanner, we developed a new type of textbooks for students with print disabilities, called “multimodal textbooks.” Since we can read multimodal textbooks with the combination of “reading printed text” and “listening correspondent speech sound to the text”, we can read them easily and correctly.

We want to study other designs of multimodal textbooks. Since the current version of multimodal textbooks was designed so that they help to improve users’ ability of reading, it might be suitable for students with print disabilities whose disorder is relatively mild. We plans to make multimodal textbooks with document structure diagrams for students with print disabilities whose disorder is relatively severe. The usage of document structure diagrams has been studied in the development of auditory testing media for test-takers with print disabilities [3].

There are 27 titles of multimodal textbooks available for students with print disabilities. From April 2014, we plan to deliver multimodal textbooks nationwide in Japan.

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