Automatic Objective Assessments of Japanese Reading Difficulty with the Operation Records on Japanese Text Presentation System
Design and Implementation

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Abstract: There are many pupils with reading difficulty in Japanese schools. The dyslexia is the disability about reading and writing texts. We use Kanji, Hiragana, Katakana characters in Japanese sentences. Based on the experiments, we show the differences between the reading activities with and without reading difficulties. This enables to make objective assessments of reading difficulty. This paper proposes the objective assessment method of reading difficulties and the design of automatic utterance detection with face images that decrease the contributions of teachers.

1 INTRODUCTION

There are many pupils with reading difficulty in Japanese elementary schools. There are many difficulties.

The big and first one is reading Japanese characters. Japanese characters are the construction of hiragana (phonetic character), katakana (another type of a phonetic character), kanji (Semantic character) and other characters. In the period of primary school, pupils learn 48 characters of hiragana, 48 characters of katakana and 1008 characters of kanji. Almost all pupils learn hiragana and katakana easily. However, the huge number of kanji is difficult to learn for some pupils in normal classes.

The next one is the difficulties about recognizing the sentence structures. In Japanese sentences, there is no spacing between words. For easing the difficulties about reading kanji characters, we can replace kanji characters with the hiragana characters. We recognize the words constructing the Japanese text in the help of kanji. There are a large number of words starting from the character of kanji. We recognize the chunk of characters that constructs a word in the complex of hiragana, katakana and kanji.

Replacing kanji characters with hiragana characters, we have the sequence of hiragana characters only. In a long sequence of hiragana, it is difficult to recognize the chunk of characters constructing a word. In our experiments, the pupils without reading difficulties like the longer high-lighted regions than the pupils with reading difficulties do. With the help of shorter high-lighted regions, some pupils with reading difficulties read more smoothly.

In an elementary school, pupils learn hiragana and katakana at first. In the first stage in elementary schools, the Japanese text-books have a space between words for the ease of understanding the structures of the sentences. However, normal Japanese texts have no space between words.

Every pupil has those 2 difficulties at first. In the long school life, they acquire the skill to conquer those difficulties. Anyway, those 2 difficulties are large barriers for reading and understanding Japanese sentences.

Every infant has no knowledge about the Japanese characters. Every pupil has a little knowledge about the huge number of kanji characters at first. Then, they learn hiragana, katakana and kanji characters in a long elementary-school life.

In Japanese elementary schools, reading difficulty means 2 years delay of reading abilities. A few of pupils with dyslexia learn in special support education schools. However, there are many pupils with reading difficulties in normal elementary

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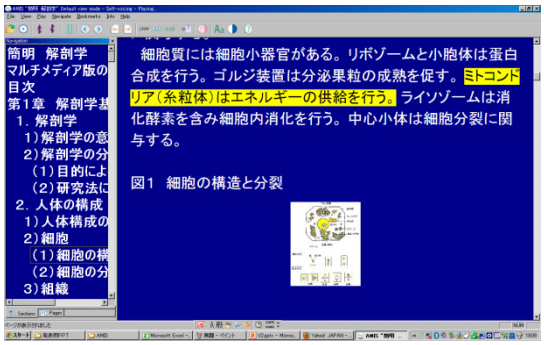

Figure 1: DAISY visual presentation example.

schools. Of course, some pupils have difficulty about remembering kanji characters. Most of the pupils remember kanji characters gradually. However, pupils with a learning disability tendency have difficulty with reading Japanese sentences in the case that they can remember the kanji characters. In the case, they may have dyslexia.

There may be many causes of the difficulties on reading Japanese texts. We do not discuss the causes. We only pay attentions to the methods for easing their difficulties. We call their difficulties "reading difficulty" in this paper.

The research about teachers shows that the pupils with ADSH tendency have difficulty about following the characters sequentially and recognizing the grammatical structures (Murayama, Aoki, 2009). Of course, there are many types of reading difficulties. There are many causes of the reading difficulties. The resulting reading difficulties show the similar symptoms. They are the difficulties about following the characters sequentially, recognizing grammatical structures and reading kanji characters.

We have developed a visual text presentation system for persons with reading difficulty in windows environments. The system records every operation of the user. With the recorded operations, we assess the difficulty of the user.

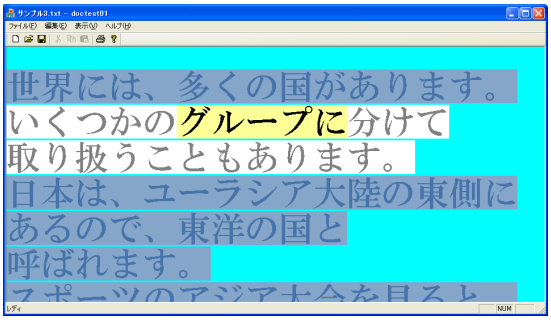

Figure 2: 1 Level annotation and 1 level mask with background coloring.

The DAISY is one implementation of digital talking book. Figure 1 shows an example of visual presentation with DAISY. It includes annotation of talking chunk of characters. It reads out the DAISY contents. It has visual text presenting functions, also (DAISY). The DAISY started for helping the people with sight disability. The DAISY is helpful for pupils with reading difficulty. However, the DAISY is a digital talking book. The content must be carefully prepared. Furthermore, there is a difficulty to make DAISY contents from electrical texts. The advanced teachers prepare the DAISY contents and use the DAISY in their classes. However, the preparations need a large amount of works. It is difficult to use emerging materials in their classes for the large preparation works. For example, it is difficult to use the morning news in the class on the same day. The interesting fresh materials can attract pupils' attentions more. The DAISY does not offer such functions. (DeMeglio, Hakkinen and Kawamura, 2002)

The Japanese text presentation system was proposed and implemented for the pupils with reading difficulties (Aoki, Murayama, 2012). The system provides the multi-level annotation as shown in figure 2. The system works well in a normal elementary school (Murayama, Aoki, 2012). The system makes the precise record of the operations. With the operational record, we can assess the reading difficulties on objective base.

This paper proposes the objective assessment method of reading difficulties with the operational record of the Japanese text presentation system, and the system decreases the work of teachers who help the pupils with reading difficulties.

First, this paper proposes the assessment method using the system operational records. Then, we discuss the problems for utilizing the assessment. Next, we propose the automatic assessment method for the pupils with reading difficulty. And last, we conclude this work.

2 OBJECTIVE ASSESSMENTS OF JAPANESE READING DIFFICULTY

With the Japanese text presentation system, the behavior of a user is recorded. From the recorded behavior, we can assess the reading difficulties about the user. This assessment is objective.

2.1 Operational Record of the Japanese Text Presentation System

The Japanese text presentation system records all the operations of a user. The Japanese text presentation system moves the high-lighted part in a text with the key-input of the user.

In using the Japanese text presentation system, the user directs the move to the next high-lighted part with a key-input. The record includes the key operations with the precise time. With the record, we can measure the time for reading the high-lighted part. Table 1 shows the example of the operational record. The 1st and the 2nd columns have the date and time. The 3rd column is the operation. The 4th column includes the high-lighted part. They are Japanese. The 5th column does the elapsed time from starting the system in 1/1000 seconds.

2.2 Assessment of Reading Difficulty

For assessing, we use the relation between the reading time and the length of the high-lighted part. There are the number of characters and the number of phonemes for measuring the length of the text. In our pre-experiments, it shows clear relations between the reading time and the number of characters. We use the number of characters for measuring the length of a text. In Japanese texts, there are kanji, hiragana and etc. As a result, there is a change of phonemes in a character. However, the number of character shows better relation to the reading time.

The Japanese text materials differ in the target age of the readers. For elder pupils, the materials include more kanji characters. A single kanji character represents a same word that is represented using many hiragana characters. Their pronunciations are same. The elder pupils read faster than the younger pupils do. As a result, there are constant relations between the number of characters and the reading time of a material.

Without reading difficulties, there is a linear relation between the reading time and the length of the high-lighted part. However, in real reading, there are many miss-operations and reading difficulties. Figure 3 shows the example of the relation between the reading time and the length of the high-lighted part. There are points on a linear function and out-lire points.

We decide the out-lire points in the reading time per character of the high-lighted part. We use a simple threshold for this process. We decide that the reading time per character without reading difficulties are between 0.1S and 0.3S. We plot the pairs of the length and the reading time of the high-lighted parts after filtering with the threshold in figure 4.

In figure 4, the pairs of the length and the reading time have the relation of linear function clearly. With the reading difficulties, the pupil needs much more reading time. As a result, the high-lighted parts where the user has difficulties for reading are plotted upper regions over the linear function.

We estimate the linear relation between the reading time and the length of the high-lighted parts from the data that are filtered with thresholds.

The data plotted in figure 4 have the relation in (1).

Table 1: Example of the recorded operations.

Date	Time	Operation	High-lighted part	Elapsed time(mS)
2013/7/4	15:42:42	RIGHT1	テレビや新聞では、	12593
2013/7/4	15:42:45	RIGHT1	天気予報が毎日伝えられています。	15375
2013/7/4	15:42:46	RIGHT1	この天気予報は、	17015
2013/7/4	15:42:49	RIGHT1	たくさんの資料にもとづいて、	19265
2013/7/4	15:42:52	RIGHT1	専門家が天気の変化を予測したものです。	22984
2013/7/4	15:42:54	RIGHT1	わたしたちは、	24250
2013/7/4	15:42:55	RIGHT1	天気予報を見て、	25765
2013/7/4	15:42:57	RIGHT1	明日の予定を立てたり、	27640
2013/7/4	15:43:00	RIGHT1	持ち物を	30281
2013/7/4	15:43:01	RIGHT1	用意したり	31250
2013/7/4	15:43:02	RIGHT1	して	33047
2013/7/4	15:44:26	LEFT3	います。	116797

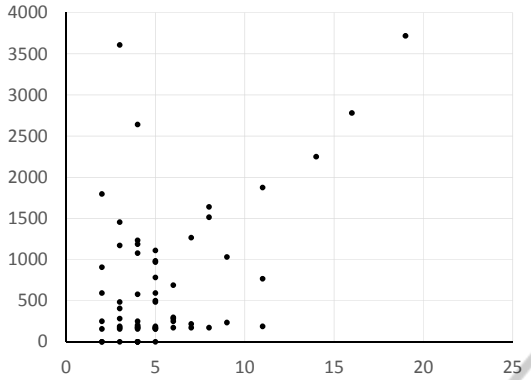

Figure 3: Relation between reading time and the length.

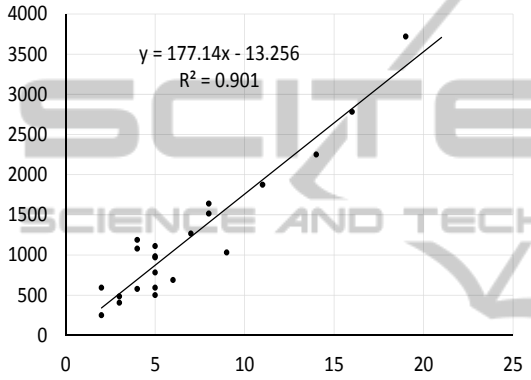

Figure 4: Relation between reading time and the length without out-lire data.

$$Y = 177.1X - 13.26 \quad (1)$$

In (1), Y is the reading time in 1/1000 second. X is the length of the high-lighted part in the number of characters.

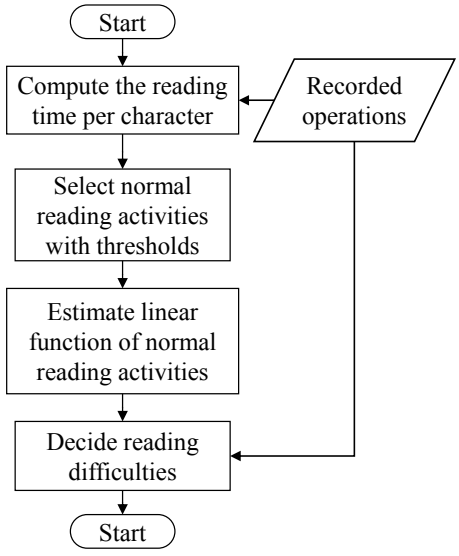

Figure 5: Assessment process of reading difficulty.

The plotted points over the normal linear function direct the reading difficulties. The corresponding part of the text shows the kinds of reading difficulties. The data under the linear function may be miss-operations. We decide that $Y \pm 1000$ is the range of normal reading activities.

The relation between the normal reading time and the length of the high-lighted part differs in the text and the school year. With large reading experiments, we can decide the normal reading activities. Figure 5 shows the process to assess the reading difficulties.

3 PROBLES ABOUT READING DIFFICULTY ASSESMENT

3.1 Teacher's Contributions

The assessment process needs large amount of teacher contributions. In reading with the Japanese text presentation system, teachers monitor the process of the readings. After that, teachers see the operational records. This assessment results an objective estimation of the reading difficulties of the user. However, there is a little difference of the teacher contributions between the assessment using the Japanese text presentation system and the classical assessment methods.

In the reading processes, a pupil may read the part that is not high-lighted. A pupil may make un-correct pronunciation. Those events make no marks in the operational record. The observing teachers guide the pupil for proper operations of the Japanese text presentation system. The teachers also record the un-correct pronunciations.

The Japanese text presentation system tries to help every pupil with reading difficulties in a normal class room. In Japanese elementary schools, there are a few pupils with reading difficulties. The teacher must make a class for the majority of normal pupils. The teachers need the day by day assessments of reading difficulties for evaluating their teaching to ease the reading difficulties of a pupil. With the present Japanese text presentation system, teachers can assess the difficulties about reading. However, the Japanese text presentation system needs many works of teachers. For enabling day by day assessments of reading difficulty, we must decrease the teacher contributions for assessing the reading difficulties.

3.2 Class Room Environments

There are many problems for utilizing the ITC technology in Japanese elementary schools (Murayama, Aoki, Morioka, 2009). The problems are listed in Table 2. For solving the problems, the proposed text presentation system treats only the electronic text. In Japan, a law forces to prepare the electronic readable texts of text books (Law). And, there are many documents accessible through the Internet. There is no paper document for an input in the proposed system.

Many pupils may remember the full text of the many times used materials as text books. Those remembered materials cannot be used for evaluating the reading performance of a pupil. The reading of the materials cannot help to enforce the reading abilities of the pupil.

In normal class rooms, many pupils use the Japanese text presentation system simultaneously. In the environments, many pupils read the text aloud. With a simple embedded microphone in PC, we have difficulties to separate each pupil's voice.

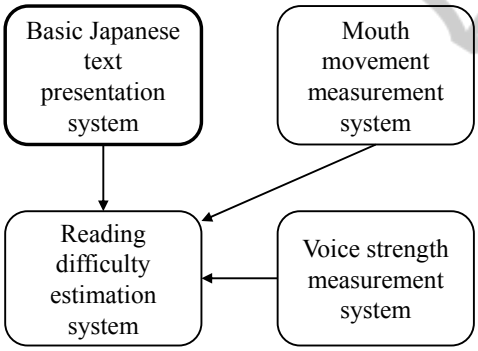

Figure 6: Japanese text presentation system with automatic assessments.

3.3 System Design

The proposed Japanese text presentation system has only 2 functions. As the first row of Table 3, we restrict the functions of the proposed system. The proposed system has some performance measurements function about pupil. This is discussed in previous section. The teachers around the pupil with reading difficulties need the objective measurements of the performance of the reading ability of the pupil. For this purpose, the proposed system provides the operation logging function. The operation logs describe the reading speed at each meaningful chunk of characters.

The proposed Japanese text presentation system enables to use one-time materials for measuring the performance of a pupil. The real-time presentation generation enables any new plain text materials at any time.

This real-time presentation generation enables to adapt the presentation for each pupil with different reading difficulties. DAISY has no function about adaptation for each pupil.

For adapting the variety of pupils' ages and disability grade, the presentation system has the function to replace the un-studied kanji characters with hiragana characters. The phonic hiragana character is first studied character. There is a little difficulty about reading hiragana.

The operations to the presentation system have the information about the user. The proposed system logs every operation with the time. This log represents the fluency of the reader.

The new system adds the video of the face images and the record of the voice to the operational record. With the video of the face image, new proposed system measure the mouth movement. With the recorded voice, the teacher may check the pronunciations afterward.

The proposed system has the features listed in Table 3. The first and the second rows are new added features. They decrease the contributions of a teacher about using the Japanese text presentation system. For wide use of the Japanese text presentation system, the system does not need large-scale contributions of teachers. The network problem is important in Japanese schools. There is a large limitation about the internet access. As a result, some cloud based implementation cannot work. The proposed system must work without the internet access.

4 AUTOMATIC ASSESSMENT SYSTEM IMPLEMENTATION

We decrease the teacher contributions with the automatic evaluation of the reading process using a microphone and a camera. The new system records the face images and the voice. The new Japanese text presentation system includes the original Japanese text presentation system. The new system includes the function to measure the mouth movement, the function to measure the voice strength and the function to make reading difficulty assessment as in figure 6.

4.1 Measurements about Voice

It is easy to measure the strength of the voice of a

user in experimental environments. With the voice of a single person, it is difficult to evaluate the precise pronunciations. However, it is easy to evaluate the strength of the voice. Figure 7 shows the wave pattern recorded with the embedded microphone in PC.

With the motions around the mouth position and the strength of the voice, the system estimates the reading activities of the user. This is much easier than to estimate the precise pronunciations.

The voice strength measurement is easy to implement. The system estimates the background noise with the measurement of continuous recorded sound. With filtered sound, we can easily estimate the voice strength of the user in the experimental environments. In figure 7, it is easy to detect the region where the voice is recorded.

In normal class room, there are many other sounds other than the voice of the user. In the environments, it is not easy to separate the voice among other voices and noises. We use the recorded voice for checking the pronunciations by the teachers.

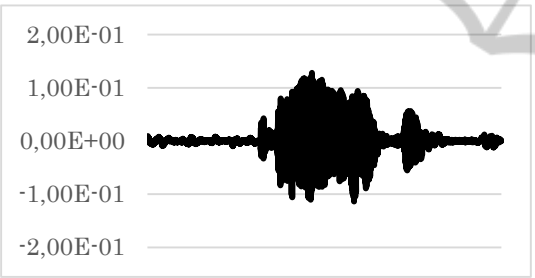

Figure 7: An example of recorded voice.

4.2 Measurements of the Motion of a Mouth

With the embedded video camera in a PC, the system records the face images of the user. Figure 8 shows an example of the processed images. The circles show the results of face and mouth detections. The figure shows the face, the eyes and the mouth clearly. The detections works well.

Figure 9 shows the measurements process of the motion of a mouth. First, face detector finds the face in an image. Then, eye detector finds the eyes. And last, the mouth detector finds the mouth in the restricted region with the detected face region and eyes' regions. As a result, mouth detector finds the mouth well. Without restriction of the search region, the mouth detector finds some number of candidates of a mouth.

Table 2: Problems about ICT usability in a special aid school in Japan.

There is a load concentration into the teacher, who is good at ICT.
There are a few educational materials for the DAISY.
They do not use the SAVE AS DAISY.
Using OCR for preparing educational materials for pupils with a learning disability tendency, the recognition errors make a large check and correct work.
There are large works for replacing difficult kanji characters with hiragana.
Using classical ICT tools as the DAISY, we need to prepare educational materials for each pupil who has a different age and a different disability.
It is difficult to evaluate the performance.

Table 3: The plan for covering the problems.

New/Old	Feature
New	Automatic operation observations.
New	Automatic assessment of reading difficulties.
Old	A collection of simple software is better than complex multi-functional software.
Old	Avoid the usage of OCR.
Old	An educational material presentation system that does not need the special material preparations.
New	An evaluation method/function for evaluating the performance of a pupil.

The system measures the motions around the mouth position. This detector is based on the face detector included in OpenCV (OpenCV). The detector has face direction compensation and face size compensations with the basic face detector. And, the eye detector estimates the eyes' positions that are not directly detected with the face detector. With the system, we can have the face and 2 eyes position continuously. With the positions both of a face and 2 eyes, we can easily estimate the mouth position relatively from the eyes' position. The mouth detector is also provided with OpenCV. In

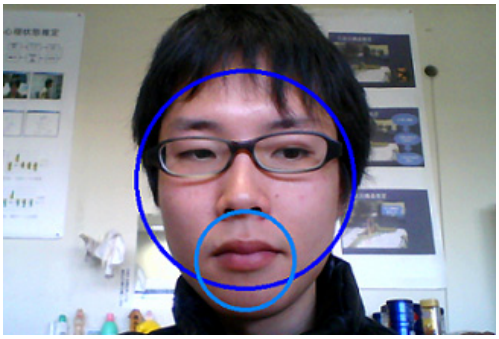

Figure 8: An example of processed images.

compensated images, the mouth detector will work well.

The face and mouth detector estimates the center and the radius of the region. With the center and the radius of the mouth's region, we decide the region of the mouth's motion detection as the rectangle circumscribing the circle describing the mouth detection. The proposed system uses this rectangle as the mouth's region.

The change of a face position is compensated with the position of the eyes. As a result, we can easily measure the mouth motions. The system measures the motion in the mouth region with the difference between adjacent 3 frames using motion template method. The method decides the mouth's region. The motion template method is also provided with OpenCV.

With this mouth motion measurement, the system estimates the reading activities of the user very precisely. With only the voice caught by a microphone, in normal classroom environment, the strength only of a voice is difficult to measure. The observation of mouth form is also difficult in normal classroom environment. However, the mouth movement only is easy enough to measure. The system measures the activity around a mouth using the motion template method.

Figure 10 shows the measured mouth's motions and utterances. The dotted line shows the utterance. The solid line shows the measured mouth's motions. The measured mouth's motion is the number of moving pixels in the mouse region. With the measured mouth's motions, we can easily estimate the utterance of a user.

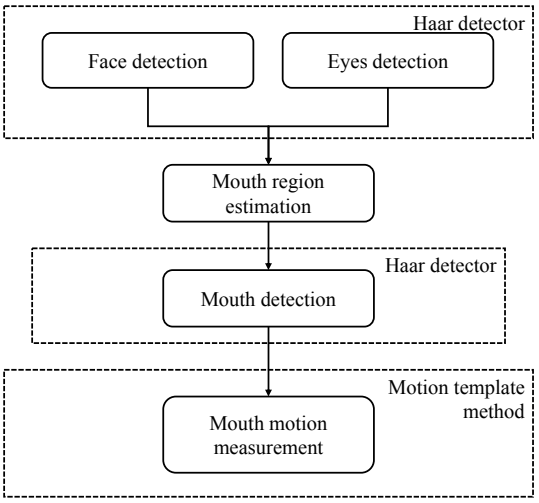

Figure 9: Mouth movement measurement.

The mouth motion measurement is robust about the changes of the environments. In class rooms, there must be proper lightings. Using the Japanese text presentation system, the user faces the display. There are no objects between the face and the display. The camera is on the top rim of the display. As a result, there is a little interception about recording the face images of the user.

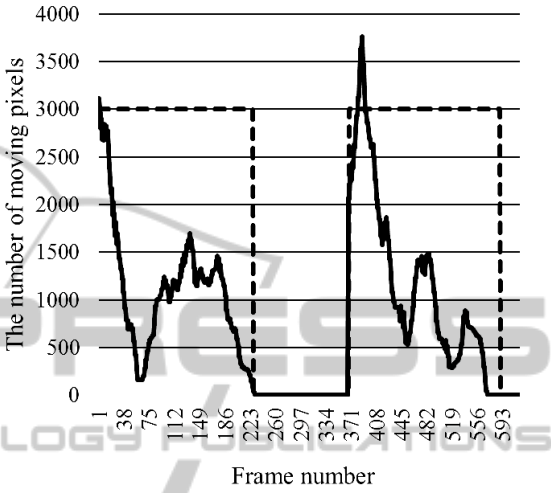

Figure 10: Measured mouth movements.

4.3 Estimation of Reading Activity

The voice of the user is easy to record using the embedded microphone in PC. It is easy to handle the recorded voice. However, in normal class rooms, there are many noises. In the environments, it is difficult to distinguish the voice of the user among many noises.

The measurement of the mouth activity is more difficult than the voice measurements, and it is time consuming. However, face image acquisition is easy and robust in the normal class room environments.

Our proposed system estimates the reading activity of the user with the video measurements of the mouth activity. When the mouth's motion is detected, the proposed system decides that the reading activity exists at the time. With this processing, the proposed system results the estimated reading activities shown in figure 11. In the figure, the dotted line shows the reading activity. The solid line does the estimated reading activity.

The error rate is 0.094 in our experiments. In a reading period, the error rate is 0.064. In a pausing period, the error rate is 0.14. With these error rate, we can check and control the operations of a user.

This implementation does not work fast enough to process in real time environments. Our implementation can process about 10 frames in 1

second. The normal video is 33 frames in 1 second. This processing speed enables to detect the utterance for teacher's checks of the automatic assessments. However, we need much more performance for assisting the user directly.

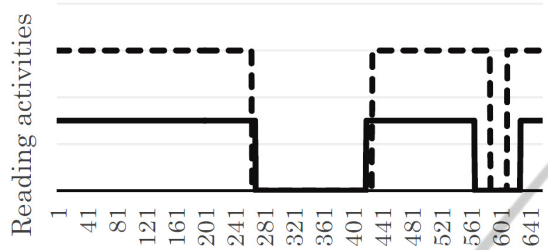

Figure 11: Estimated reading activities.

5 CONCLUSIONS

The proposed Japanese text presentation system reports the precise reading activities of the user to the teacher. The report includes not only the key operations, but also the timing of utterance with video analysis. The utterance timing is a direct description of the user's reading activities.

The proposed Japanese text presentation system with automatic assessment enables to be used simultaneously in a class room. In normal class room, a teacher controls many pupils, including ones with reading difficulties.

The new proposed system decreases the contributions of a teacher for using the Japanese text presentation system in a class. Teachers do not need to check all record of the user's reading activities. The system detects the points where the reading difficulty is. This enables easier use of the Japanese text presentation system in normal class rooms.

The much more precise record of the user's activities helps to evaluate the precise assessment of the reading difficulties with less teacher's work.

The next step of this research is a wide distribution of the software. However, this needs not only the software distribution, but also the distribution of the method to use the software effectively.

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