Reading Notes as Media to Enrich Communications between Reader and Book

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2020 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE) | 978-1-6654-1974-1/20/$31.00 ©2020 IEEE | DOI: 10.1109/CSDE50874.2020.9411521

***Abstract*— People have considered that "Reading" has many advantages for a long time. However, in recent years, the decrease of reading of young people has become a serious problem in Japan. Postulating that reading is communication between a reader and a book, we define the importance of reading as giving readers intellectual stimulation, exciting creativity, and expanding their inner world. In reading, a book has no reaction to the reader, and it prevents the reader and the book from interacting. To solve this problem, we propose a new type of reading notes as media that intermediates interactions between them. Since people had to take considerable time and effort to take reading notes so far, we use gaze information generated through his/her reading behaviors. Readers change reading patterns depending on the difference of interest in and difficulty of the contents of books. Therefore, gaze information represents reader's mind about the book. We think it useful to create reading notes. Researches on gaze information and reading have been conducted so far. However, these studies don't aim to create reading notes that reflect reader's mind. We propose an automatic reading notes creating system using reader's gaze information during reading.**

Keywords*— *Reading, Reading notes, Communication, Media, Gaze Information

I. INTRODUCTION

People have considered that "Reading" has many advantages for a long time. The recent research found that the childhood reading experiences has a good influence on adult consciousness, motivations, and activities [1]. On the other hand, in recently, the increase of young people who don't read books has become a serious problem in Japan. According to the latest survey about college students which is conducted by National Federation of University Co-operative Associations (NFUCA) every year, the percentage of students who spend no time reading books in a day is 48.0% [2].

Reading gives readers surprise, knowledge, and intellectual stimulation, excites imagination and creativity, and expands their inner world. If reading has such importance , the survey result shows that many people don't understand it.

The research concept we introduced for that purpose is to postulate that reading is communication between a person and a book. An idea is to achieve interactions between them through a mechanism to feedback a reading note as response to the gaze information a reader generates during reading as stimulus.

To enable people to re-recognize and rediscover the importance of reading, we propose a new type of reading notes as media that intermediates interactions between a person and a book. However, people have to take considerable time and effort to take reading notes. In this research, we use gaze information generated through his/her reading behaviors. Readers change reading patterns depending on the difference of interest in and difficulty of the contents of books. Therefore, gaze information represents reader's mind about the book. We think it useful to create reading notes. Researches on gaze information and reading have been conducted so far. However, these studies don't aim to create reading notes that reflect reader's mind.

The purpose of this study is to build the system that create automatic reading notes by gaze information during reading.

II. CREATION OF READING NOTES AS MEDIA

A. Importance and application of communication

In this study, we postulate that reading is communication between a person and a book.

There is an idea that the importance of the communication between people is defined as the expansion of one's inner world by exciting imagination and creativity each other [3]. We cannot completely understand and predict someone to communicate with. However, we feel various emotion and get unexpected information by communication with unpredictable people.

If reading is assumed to be the communication between people and books, can reading arouse imagination and creativity, and people expand the own inner world?

B. Problem of reading as "communication between a person and a book"

We explained the importance of reading, but people who experience it enough is few. In reading, a book has no stimulus to receive from the reader, let alone no reaction to respond to the reader. That is, it prevents both the reader and the book from interacting. To solve this problem, we use reading notes as a kind of feedback from the book to the reader's gaze

information during reading as a kind of stimuli from the reader, as shown in Fig. 1.

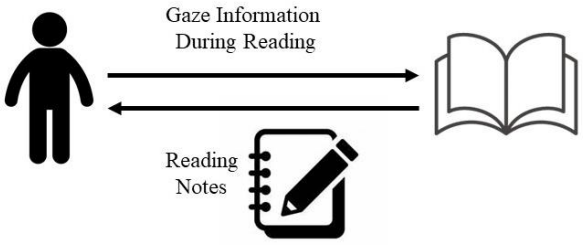

Fig. 1. Communication between a reader and a book

C. *Reading notes as media*

In this study, reading notes not only helps to communicate between the reader and the book but also plays a role as media which mediates interaction between them. Reading notes record words and sentences which extends reader's inner world: unknown knowledge, favorite expression, idea, and so on. Reading the notes again after time pass, people remember various emotion, thought, and memory, and get new discoveries about themselves and feel their changes.

D. *Gaze information during reading*

We use gaze information generated through his/her reading behaviors to create the reading notes. People change reading patterns depending on the difference of interest in and difficulty of the contents of books. For example, they read interesting and difficult part repeatedly and glance or skip unimportant part. Therefore, gaze information shows reader's mind about the book. We think that it is useful as the feedback from books to people to create reading notes.

To identify a part of book to interest a reader, other modalities such as line maker and voice utterance are available. We employed, however, the gaze information of a reader for that purpose from the following two reasons.

The first reason is that the gaze information doesn't pose any action and operation to extract sentences from a book to a reader. In the cases of using line marker and/or voice utterance to note, for example, the reader has to trace it with his/her finger and/or make his/her voice. Those action and operation should give inconvenient to the reader under some situations in which he/she feels difficulty to do so.

The second reason is that gaze information often implies a reader's unconscious mind and will on the content of book. In the case of creating reading notes with line maker and/or voice utterance, the reader should intentionally select words and sentences to take it. The reader can do the same thing too with eye movement defined for such action, for example, blinking 3 times, at the starting and finishing point to record. However, we emphasize again that gaze information implies the reader's unconscious mind and will. The reader might read repeatedly not only an interesting part but also a difficult part to understand. In this research right now, we investigate a possibility of gaze coordinate only, but there should be a possibility for a system to be able to judge that the coordinate would be selected whether consciously or unconsciously by introducing other parameters such as the speed of eye movement and the change of pupil diameter into a system.

We postulate that a reading note involving parts that a reader doesn't select should make some difference as media from one involving only part that the reader intentionally selects for record.

E. *Automatic reading notes creating system*

We have 3 purposes to enable people to re-recognize and rediscover the importance of reading as follows:

1. Suggestion on automatic reading notes creating system using gaze information during reading
2. Investigating the influence of reading notes on the cognitive characteristics
3. Propose a new type of reading notes as media that intermediates interactions between the reader and the book

We aim to build the system shown in the first purpose to achieve the second and third ones. Fig. 2 shows the process of the suggested system. To guess reader's mind about the contents of the book, the reading patterns are identified by gaze information. The book data is skimmed by reading screen information where the reading pattern happened. Reading notes is created and shaped using it.

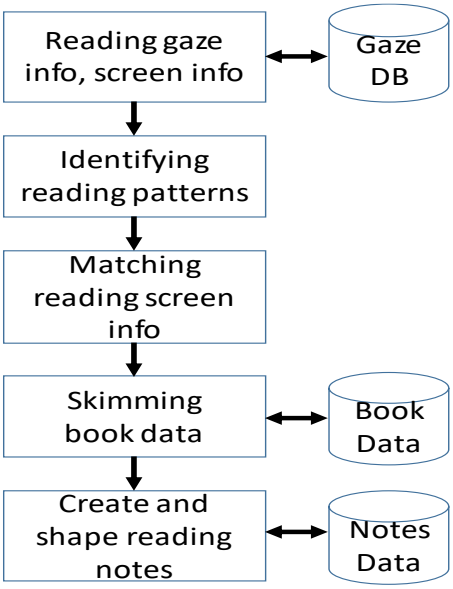

Fig. 2. Process of creating reading notes by gaze information during reading

III. RELATED RESEARCH

Research about gaze information and reading have conducted since before. For example, there is the research that use eye features to detect reading behaviors [4]. The final goal of this research is to create reading life log automatically. The reading life log is the long-term digital recording that when, what, and how people read in a daily life [5]. In this related research, the experiment to detect reading behavior in the daily activities with mobile eye tracker was conducted. The researchers compared the accuracy of 4 methods: Bulling et al. [6], Yoshimura et al. [7], Kunze et al. [8], and all these methods. The purpose of this study is detecting reading behaviors, not creating reading notes.

In the support of reading by eye tracking, there is the research to track eye movement during reading an e-book and show the point at where people leave off reading [9]. The point

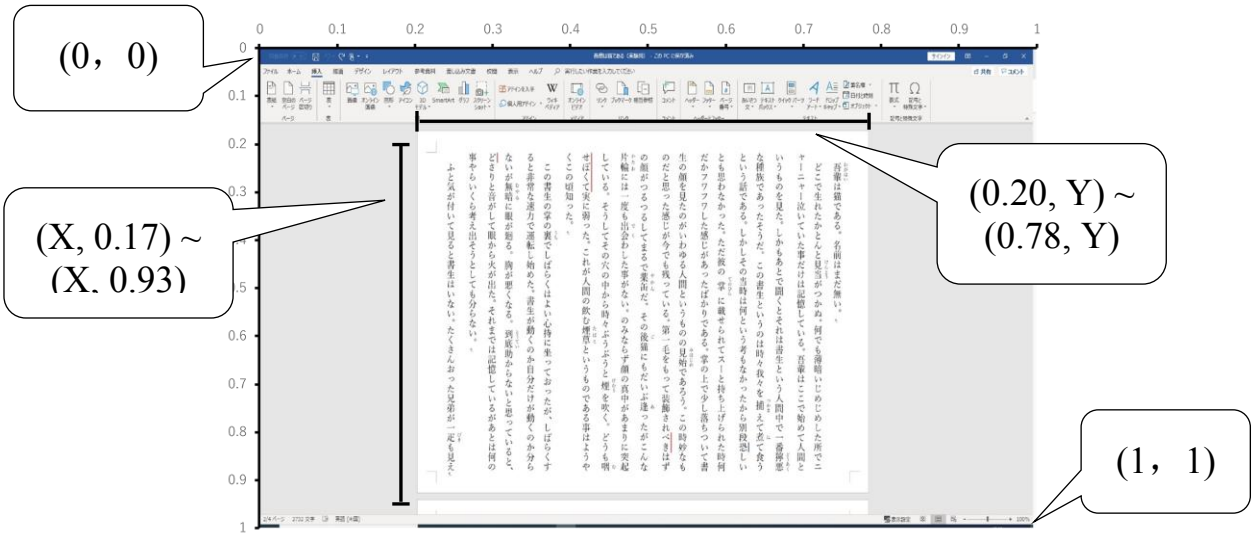

Fig. 3. Coordinate of reading screen

is shown by changing the color of part that people finish reading.

These studies don't aim to create reading notes that reflects reader's mind.

IV. EXPERIMENT

The purpose of this paper is building the automatic reading notes creating system introduced in the section II-E. As the first step, we measure gaze information during reading a book and examine how to identify reader's reading patterns.

A. Eye tracker

We used Tobii Pro X3-120 which is the eye tracker provided by Tobii Technology Company [10]. It gets coordinates of left eye and right eye per 1/120 second: the sampling rate is 120Hz. The axis of coordinate puts (0, 0) on the upper-left of the screen and (1, 1) on the lower-right. In the document area for this experiment, the range of X coordinate is 0.20~0.78, the range of Y coordinate is 0.17~0.93. Fig. 3 shows the reading screen and the coordinates.

B. Reading patterns

We measure gaze information of 4 reading patterns as follow:

1. Along sentences: read document from the beginning to the end.
2. Repeat: read a direction sentence twice repeatedly.
3. Return: after reading until the direction sentence of the end side, return to that of the beginning side.
4. Skip: after reading until the direction sentence of the beginning side, skip to the next sentence of that of the end side.

The direction sentences for cases 2~4 are changed to red.

C. Document for experiment

To create a document for this experiment, we referenced Soseki Natsume "I am a cat" published on the Internet [11]. TABLE I shows the layout detail of the document. A participant read only the first page displayed on the screen. TABLE II shows the coordinates of the direction sentences for cases 2~4.

TABLE I. LAYOUT DETAILS

Paper orientation	Lateral
Character orientation	Vertical writing
The number of lines	21 lines
The number of letters per line	33 characters
Margin sizes	Upper, Under, Left, Right: 12.7mm

TABLE II. COORDINATE OF SENTENCES CHANGED RED

	X	Y
case 2	0.44 ~ 0.46	0.32 ~ 0.79
cases 3 and 4	beginning side: 0.39 ~ 0.44 tail side: 0.56 ~ 0.61	0.21 ~ 0.89

V. RESULTS AND DISCUSSION

Fig. 4-8 show results of data averaged and processed by smoothing with sliding window. The sampling rate of the eye tracker is 120 Hz, but the raw data is too many for analyzing it. We took the average every 12 data: per 1/10 second. When people stare a point voluntarily, eyes vibrate involuntarily. It is called involuntary eye movement during fixation. It causes the experiment result to include a many vibration. Therefore, we performed the smoothing processing by sliding window. sliding window needs a window width and a sliding width. We decide that the window width is 6 and the sliding width is 2. It means that these values are calculated by averaging data for 600 ms with every 200 ms difference. In the figures, the ranges of red and green indicate the coordinates of the direction sentences shown on TABLE Ⅰ. In the case that has 2 direction sentences, the green is the beginning side, the red is the end side. The range of yellow indicates the section in which the characteristic eye movement of each case occurs.

Fig. 4 and 5 shows the results of case 1. An experiment participant moves eyes from upper to lower and from right to left in Fig. 3. The expected eye movement of X coordinate is

from (1, y) to (0, y). The one of Y coordinate is the oscillation between (x, 0) and (x, 1). Fig. 4 and 5 records the explained motion.

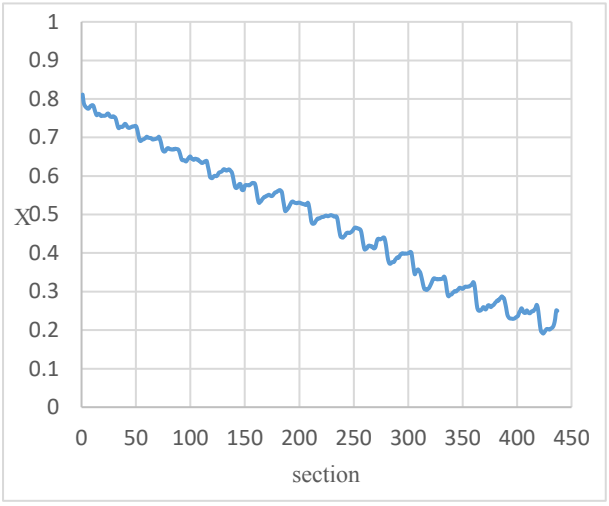

Fig. 4 Result of case 1 (X coordinate)

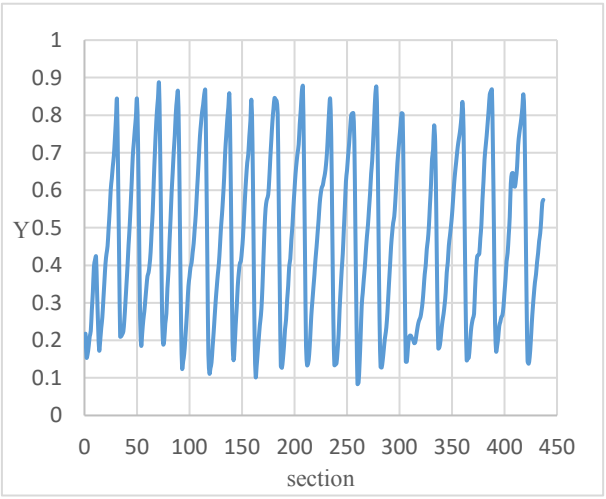

Fig. 5 Result of case 1 (Y coordinate)

The results of Y coordinate of case 2 are shown in Fig. 6. In the second experiment, a participant read the direction sentence twice repeatedly. In Fig. 6, the motion that eyes move from the end of the direction sentence to its beginning is observed.

The result of X coordinate of the third experiment is shown in Fig. 7. The X-axis motion is expected that eyes move from (0, y) to (1, y). In Fig.7, the expected movement is observed.

The result of X coordinate of case 4 is shown in Fig. 8. The motion is expected that eye move from (1, y) to (0, y). In Fig. 8, the expected movement is observed.

The results show that the characteristic eye movement differs depending on the reading patterns. Therefore, it is possible to identify the reader's reading patterns from the change of gaze coordinate. Especially, in vertical sentences, the analysis of the eye movement of X coordinate is useful for identifying the 4 patterns measured in this experiment. In addition, the analysis of Y direction is useful for identifying where the eye movement started and ended within a line.

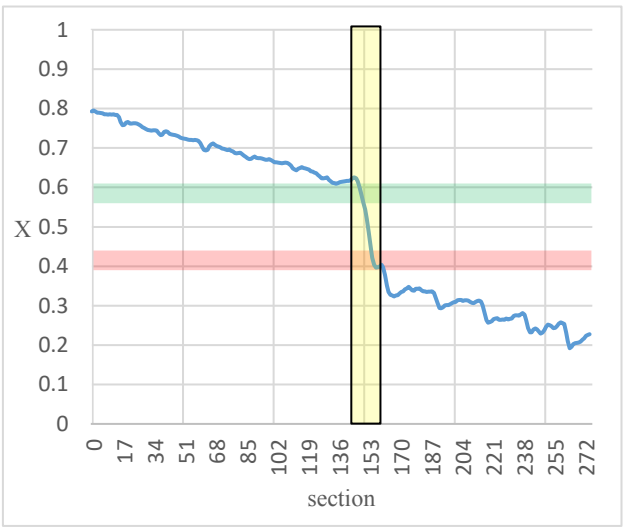

Fig. 6 Result of case 2
(Y coordinate / R: y=0.32 ~ 0.79)

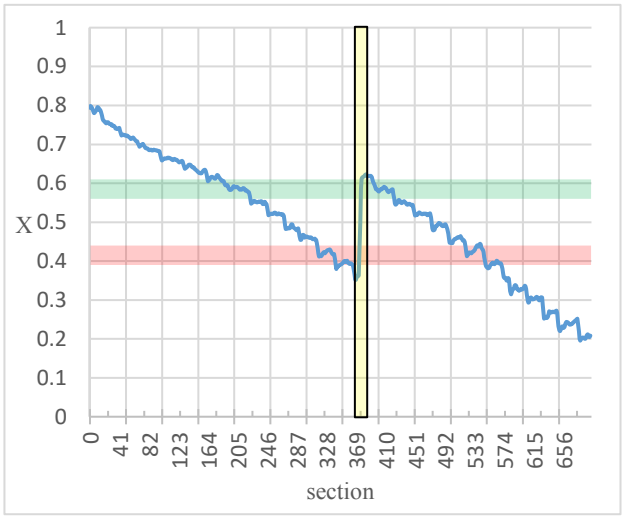

Fig. 7 Result of case 3
(X coordinate / R: x=0.39~0.44, G: x=0.56 ~ 0.61)

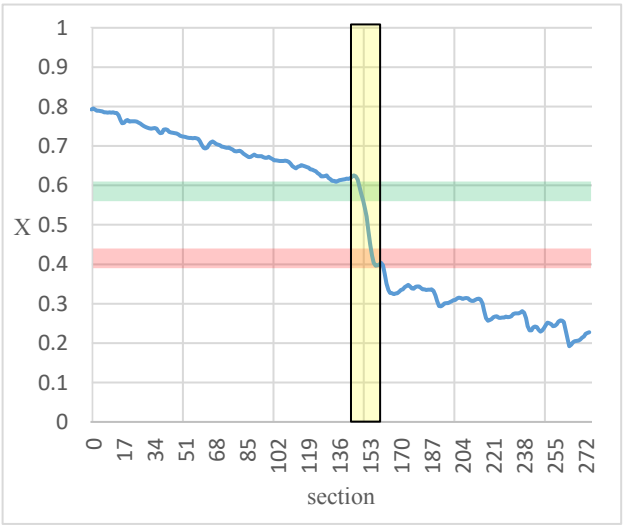

Fig. 8 Result of case 4
(X coordinate / R: x=0.39~0.44, G: x=0.56 ~ 0.61)

VI. CONCLUDION

The aim of this study is to enable people to re-recognize and rediscover the importance of reading. The research concept we introduced for that purpose is to postulate that reading is communication between a person and a book. An idea is to achieve interactions between them through a mechanism to feedback a reading note as response to the gaze information a reader generates during reading as stimulus.

Thus, we proposed a new type of reading notes as media that intermediates interactions between a person and a book. And, we investigated a possibility to create automatic reading notes by analyzing gaze information during reading. As the results, we could show that the characteristic eye movements differ depending on the reading patterns. We have confirmed it possible to identify a reader's reading patterns from the change of gaze coordinate.

As the future work, we are pursuing various possibilities of reading notes as media to enrich communications not only between a reader and a book but also between a reader and other readers as well as between a book and other books.

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