UNKNOWN ENGLISH WORDS AUTOMATIC DETECTION SYSTEM WITH EYE-TRACKING

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ABSTRACT

When reading a document written in English, sometime unknown English words are found. In such a case, these words are looked up in a dictionary. However, when it occurs frequently, it is troublesome since it takes a lot of time. Aiming at reading English documents smoothly, this research proposes a system which automatically detects unknown English words in a document on the computer screen with the user's line of sight. This system detects the coordinate of the screen where the user is looking at by using an eye-tracking device. When reading a document naturally, the reader's line of sight moves from the left side to the right side, then returns to the left side towards the beginning of new line. However, when the user finds an unknown English word and does not understand the sentence, the user's line of sight does not move smoothly. Therefore, it is assumed that if the user's eye-movement slows down drastically, the corresponding word to the coordinate can be an unknown word. If the unknown words can be correctly detected in real-time by this way, the translated meanings in the native language can be displayed or provided by voice message. The reader does not have to use the keyboard or the computer mouse to look up the unknown English words in the dictionary. In this paper, the research background based on the authors' experience and the research purpose will be explained. Subsequently, the related work with the pros and cons, and the principle of the proposed system will be described. After that, the system implementation will be thoroughly stated. To show the effectiveness of the proposed system, the preliminary results obtained by some experiments will be discussed. Finally, the paper will be concluded with the future work.

1. INTRODUCTION

When doing any research, reference literatures, especially international journals written in English are needed to survey the previous researches. But, it takes a lot of time for Japanese whose native language is not English to read and understand the literatures. When reading English literatures, the most of time is taken to look the meaning of unknown words up.

This research aims at reducing time for reading English literature. To achieve this, two issues must be solved. One is to automatically detect unknown English words using the reader's eye-tracking. The other is to display the meanings of the unknown English words on the computer screen. The second one is not difficult technically, and thus the first one will be focused on in this paper. Here, there is a hypothesis that the eye movement of the reader would slow down when an unknown English word is found.

In this paper, the threshold value of eye movement speed that shows the unknown English word detection will be investigated through an experiment. In addition, the detection accuracy based on the threshold value will be discussed.

2. PROPOSED UNKNOWN ENGLISH WORD DETECTION

As mentioned in Introduction, the eye movement speed is used to detect unknown English words. When the eye movement has slowed down for more than 220 ms, it is regarded that the reader may find an unknown English word. This value was decided referring to a research on word processing time [1]. Actually, in verification experiments in this study, the eye movement speed (pixel/sec) is measured by an eye-tracking device every 0.033s, and thus the above value of 220 ms corresponds to about 7 data points (0.033x7=0.231). If the eye movement speed is less than a threshold value v in more than consecutive 7 data points, the word the reader is gazing at is regarded as an unknown English word.

The purpose of this study is to clarify the appropriate

threshold value v to detect unknown English words with the detection accuracy. Therefore, the detection accuracy varying the threshold value v is discussed. However, even though the proposed method decides unknown English words, they may not the unknown English words for the reader, hence, the correctness of detection is also used as an evaluation metric of the proposed method.

3. EVALUATION EXPERIMENTS

To evaluate the proposed method, firstly, the following two things must be verified. One is to detect that the eye movement speed slows down, namely, the reader gazes at somewhere on the computer display. The other is to detect the gazing points which correspond to the places of unknown English words. Therefore, the detection accuracy of gazing points in the situation where the reader was deliberately gazing at specified words was investigated.

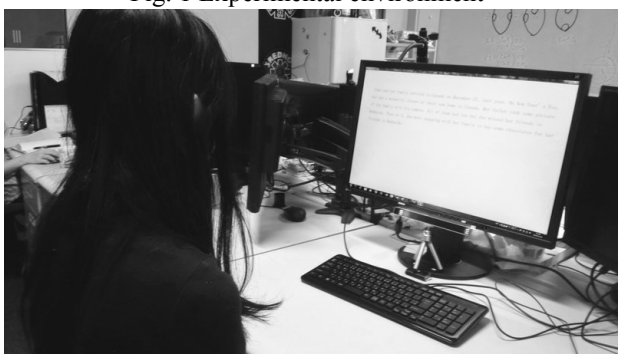
Even though the reader deliberately gazes at unknown English words, the meanings of them can automatically be displayed on the computer screen, and thus the purpose of this study would be achieved. However, such a human-computer interface is not user-friendly. Unknown English words must be detected even when the reader is not deliberately gazing at specified words unlike in the above case. Therefore, the detection accuracy of unknown English words in the situation where the reader was reading English sentences naturally was investigated.

To evaluate the proposed method from the viewpoints stated above, two types of experiments were conducted. The specification of devices used in this experiments and the experimental environment are shown in Table 1 and Fig. 1, respectively.

Table 1 Device specifications

Eye-tracking device	The Eye Tribe Tracker
Display	Flex Scan EV2436W (1920×1200[pixel])
Personal computer	mouse computer LM-iHS200S

Fig. 1 Experimental environment



3.1 Experiment for gazing points detection

In the first experiment, the situation where the subject was gazing at the specified words deliberately was considered in order to confirm whether gazing points can be detected or not. The subject was reading 4 lines easy English sentences displayed on the computer screen as shown in Fig. 1. In advance, three English words in the sentences had been selected as deliberate-gazing points. The subject gazed for 2 seconds when those three words were found while reading. This measurement was repeated 50 times for three different sentences. The threshold value v was varied from 30 to 80 pixel/sec to calculate the detection accuracy of deliberate-gazing points.

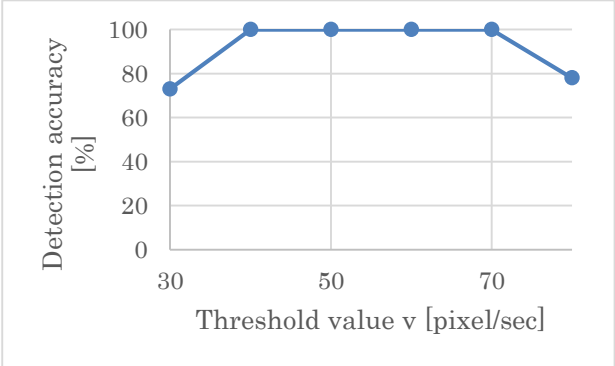


Fig. 2 Detection accuracy of deliberate-gazing points

Figure 2 presents the detection accuracy of deliberate-gazing points. The result shows that the detection accuracy is 100% for all the sentences when the threshold value v varies from 40 to 70 pixel/sec.

3.2 Experiment for unknown English words detection

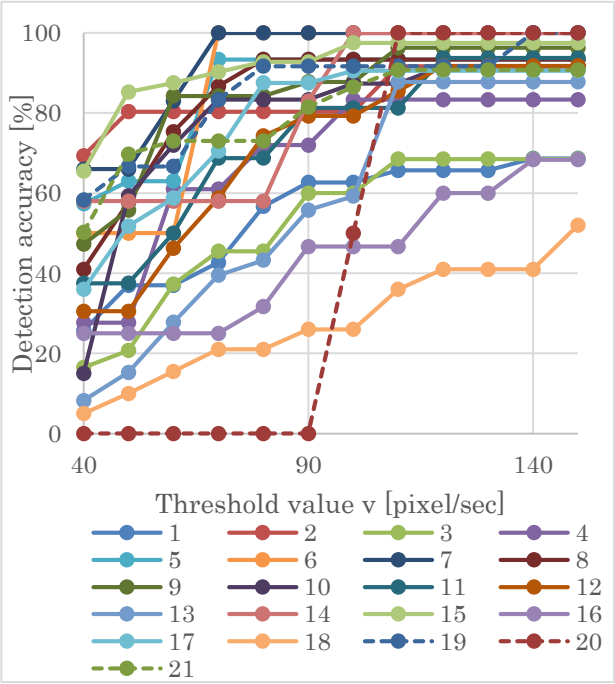


Fig. 3 Detection accuracy of unknown English words

In the second experiment, the situation where the subject was reading English sentences naturally was considered in order to confirm whether unknown English words can be detected or not. The subjects seriously read 7 lines English sentences on the computer screen. Note that these English sentences were extracted from

university entrance examinations. After the experiment, each subjects declared which English words were unknown. This measurement was conducted to four different sentences. The threshold value v was varied from 40 to 150 pixel/sec to calculate the detection accuracy of unknown English words.

21 Subjects who were early twenties joined this experiment. Note that subjects who were good at English tended to read the sentences quickly so that unconscious-gaging cannot be detected. Therefore, the number of adequate subjects were limited.

Figure 3 presents the detection accuracy of unknown English words. The result shows that the detection accuracy for all the sentences increases when the threshold value v increases. When the threshold value v approaches 150 pixel/sec, the detection accuracy for 5 subjects is 100%. Moreover, the detection accuracy for 15 subjects reaches more than 90%.

The result of Fig. 3 clarified that unknown English words can be detected with high accuracy. This accuracy indicates the rate of the number of detected unknown English words to the total number of unknown English words that the subjects declared. Therefore, the correctness of unknown English word detection by the proposed method is not considered. Here, the correctness of unknown English word detection is defined as the rate of the number of true unknown English words to the total number of unknown English words that the proposed method estimated.

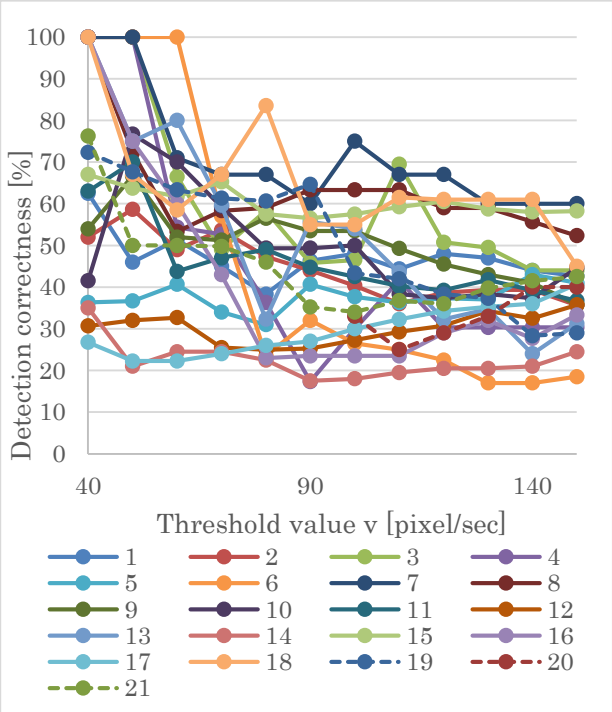


Fig. 4 Correctness of unknown English words detection

Figure 4 presents the correctness of unknown English words detection. This result shows that the correctness of detection tends to increase when the threshold value v decreases.

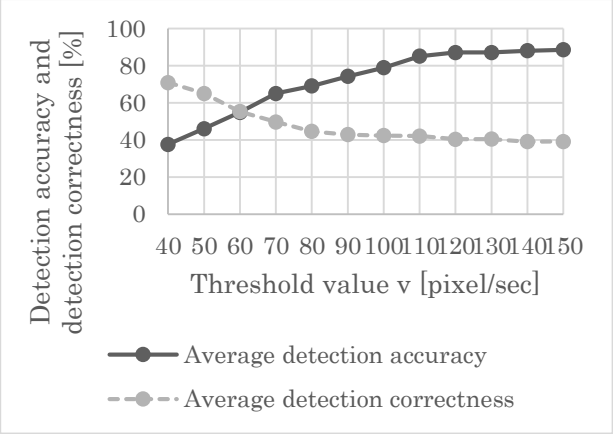


Fig. 5 Relation between detection accuracy and detection correctness

From the results of Fig. 3 and Fig. 4, it is clear that the detection accuracy increases when the threshold value v increases, and the detection correctness increases when the threshold value v decreases. The threshold value v must be determined to achieve the highest performance of the proposed method. However, these two tendencies are contradictory. Therefore, the optimum value for the threshold v should be determined.

Figure 5 represents the relation between the average detection accuracy and the average detection correctness varying the threshold value v. As seen in Fig. 5, the two line intersect at the threshold value v of 60. Hence, the optimum value for the threshold v can be determined as 60 pixel/sec.

4. DISCUSSIONS

4.1 Detection accuracy deterioration

From the result of Fig. 3, it reveals that the detection accuracy increases when the threshold value v increases. However, the accuracy of some subjects does not reach 100%. This is because of the following issues.

(1) unknown English words are placed consecutively
(2) unknown English word is placed at the beginning of a line
(3) subject is wearing contact lenses
(4) the head of subject moves during the experiment

For the issue (1), for instance, if two unknown English words are placed consecutively, the first one can be detected based on the proposed method, however, the eye movement keeps the slow speed to the second one as well without the boundary. Currently, the proposed method adopts 220 ms as the analysis time interval based on the processing time for one word as stated in Section 2. Therefore, this condition should be reconsidered to solve the issue (1).

For the issue (2), the subject's eye balls move quickly from the end of the previous line to the beginning of the next line. In this case, the eye movement speed becomes unstable. Therefore, the word at the beginning of a line

was deselected in the unknown English word detection process. To overcome this difficulty, a new approach is required based on the investigation of eyeball movements.

The issue (3) arises from the capability of the eye-tracking device used in this study, and thus this solution is out of scope here. The issue (4) can be solved by instructing the subjects not to move the head during the experiment. However, this is not recommended since it is not natural. If the movement of the head can automatically be detected, the eye-tracking coordinates might be corrected. This will be one of the future studies.

4.2 Detection correctness deterioration

From the result of Fig. 4, it reveals that the detection correctness increases when the threshold value v decrease. However, the detection correctness is not satisfactory compared to the detection accuracy. This is because of the following issues.

(1) unknown English words are placed close to a comma or period
(2) one sentence is too long
(3) there are emphasized or important words
(4) word length is too long

When a comma or a period is found when reading, the reader tends to take a pause. Also, the same thing may happen if one sentence is too long, emphasized or important words such as conjunction and relative pronoun are used, and the length of a word is too long. It is difficult to solve all the above issues. One of the possibilities to overcome these difficulties is the use of machine learning technique. If the reader's reading pattern can be trained, the issue (1) to (4) could be detected, and thus the detection correctness could be improved.

5. CONCLUSION

In this paper, a new method to detect unknown English words using an eye-tracking device was proposed aiming at reducing time for reading English literature. The proposed method focused on the reader's eye movement speed and a hypothesis was formed; the eye movement speed decreases when an unknown English word is found since the reader would gazes at the word.

To verify if the gazing points can be detected or not, two types of evaluation experiments were conducted. The first experiment was performed in the situation where the subject was gazing at the specified words deliberately. From the result of the first experiment, it was clarified that the detection accuracy of gazing points is 100% when the threshold value of the eye movement speed is from 40 to 70 pixel/sec. The second experiment was performed in the situation where the subject was reading English sentences naturally. The second experimental result revealed that the detection accuracy increases when the threshold value of the eye movement speed increases, and the detection correctness increases when the threshold value. Therefore, the optimum value for the eye movement speed was obtained, which is 60 pixel/sec.

The reasons to deteriorate the detection accuracy and the detection correctness were discussed and some solutions and the possibilities were described as future studies.

REFERENCES

[1] Koichi Kaketa, "Word recognition process in reading: A review of studies on eye movement recordings," Bulletin of department of literature, Hokkaido University, 46(3), pp.155-192, 1998.

[2] Emi Yanagisawa, Rie Ooki, Mika Suzuki, "Characteristics of the Reading Processes, as Observed through an Eye-Camera," Bulletin of Japanese Language Center for International Students, Tokyo University of Foreign Studies, 16(1), pp.46-47, 2009.

[3] Takanori Hayashi, Yuichi Muto, Isami Nakajima, "Subjective Quality Evaluation on Response Time in Web Service," Proceedings of IEICE General Conference, Communications (2), pp.614-614, 2001.

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