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Interactive Learning Support User Interface for Lecture Scenes Indexed with Extracted Keyword from Blackboard

[1]S. Okuyama, [2]S. Tsuruoka, [1]H. Takase, [1]H. Kawanaka, [3]C. Premachandra

[1]*Graduate School of Engineering, Mie University,1577 Kurimamachiya-cho, Tsu-city, Mie 514-8507, JAPAN.*
[2]*Graduate School of Regional Innovation Studies, Mie University,1577 Kurimamachiya-cho, Tsu-city, Mie 514-8507, JAPAN.*
[3]*Graduate School of Engineering, Tokyo University of Science,6-3-1 Niijuku, Katsushika-ku, Tokyo 125-8585, JAPAN.*

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ABSTRACT

Recently, video based e-learning systems have been proposed. Here, lecture videos are stored in a database and student can search desired lecture scene by keyword search. For achieving the keyword search, keyword registering is important and it is hard to register keywords manually. To solve this problem, we are constructing a new visual e-learning system with a function of automatic keyword indexing. This function needs keyword extraction from blackboard image, however, this system has two problems. The first problem is that keyword extraction accuracy is not enough due to the errors of the character segmentation, and second problem is that students cannot search desired lecture scenes effectively with the previous user interface. In this paper, we discuss a new character segmentation method to improve the keyword extraction accuracy. According to the experiments, the new character segmentation method showed better performance than previous one. The character segmentation rate is improved 6.0% (79.1% to 85.1%). As a result, the keyword extraction for developing e-learning system from blackboard images could be improved (78.6% to 80.0%).On the other hand, this paper presents an improvement of user interface.In the previous user interface, it takes considerable time for searching desired lecture scenes. To solve this problem, we propose a new interactive learning support user interface. This system has a keyword search function, which includes automatic keyword indexing by extracting keywords from blackboard lecture scenes. The proposed user interface reduced to one-ninth of the search time of lecture scene with keyword search. We also add an interactive learning support function which students can learn unknown keyword immediately in watching the lecture scene to use electronic textbook and web search. We conducted questionnaire for 10 students to evaluate the proposed method. The questionnaire results also showed the better usability of the proposed interactive learning support user interface.

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INTRODUCTION

E-learning system is useful to improve the student's academic ability. The video e-learning systems delivering presentation slides and lecture movies have been developed by using the presentation software (P.Chiu, A.Kapuskar, S.Reitmeier and L.Wilcox, 1999). However, the lecture using a blackboard is still popular lecture style in the universities and preparatory schools (S. Ichimura, 2007). Recently, e-learning systems for recording lecture using a blackboard and delivering them to students have been developed. For example, P4Web system constructed by Earnet Co., Ltd. was commercialized. In these e-learning systems, one of the main problems is to register the keyword indexes manually for keyword search. Yaginuma, (2007) proposed a keyword extraction method from slide images for automatic keyword indexing. However, automatic keyword

Corresponding Author: Shohei Okuyama, Graduate School of Engineering, Mie University, 1577 Kurimamachiya-cho, Tsu-city, Mie 514-8507, JAPAN.

indexing to blackboard lecture scenes is still very challenging problem, because handwritten keyword extraction from blackboard image is very difficult. To solve this problem, we are constructing a new visual e-learning system with a function of automatic keyword indexing. Fig. 1 shows the structure of our visual e-learning system with three cameras. These three cameras are installed on the back wall of the classroom to focus the blackboard.

1). The cameras capture three lecture movies. Student can watch three types of lecture video as entire lecture movie, blackboard writing movie and lecturer tracking movie.

2). The captured lecture videos are separated into each lecture scene(S.Okuni, S.Tsuruoka, G.P.Rayat, H.Kawanaka and T.Shinogi, 2007).

3). This system extracts keywords from each lecture scene to register keyword index automatically.

4). Students can search and watch desired lecture scene by keyword search.

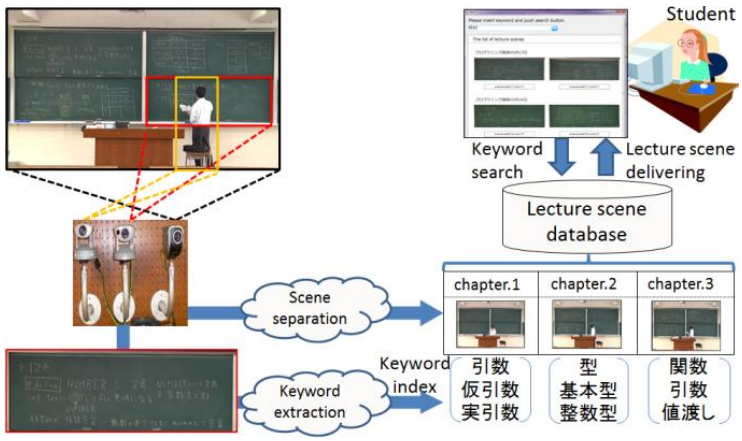


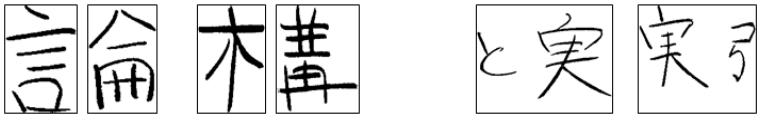
Fig. 1: Structure of visual e-learning system

However, this system has two problems. The first problem is that keyword extraction accuracy is not enough due to the errors of the character segmentation process at the character recognition step, and second problem is that there is no user interface to search desired lecture scene by keyword. Furthermore, students cannot learn unknown keyword immediately in watching lecture scene.In this paper, we discuss a new character segmentation method which improves the character recognition. As a result, we could improve the keyword extraction accuracy. This paper also discusses a new interactive learning support user interface and itsusability.

2. Methodology:

Keyword Extraction:

In the previous method, the character segmentation was conducted following the character recognition and width/height ratio of a character (S.Okuyama, S.Tsuruoka, H.Takase and H.Kawanaka, 2012). However, that methodwas not so effective,in some cases, mis-separated characters or mis-connected characters were extracted (Fig. 2).



(a) mis-separated characters (b) mis-connected characters

Fig. 2: Mistakes of the character segmentation (previous method)

In this paper,we discuss a new character segmentation method for achieving keyword extraction. This time, a gap between characters, results of character recognition and the width/height ratio of a character are used to solve the problem of previous method. The main steps of the proposed keyword extraction method can be explained as below.

1). This system binarizes blackboard image using Otsu's binarizationmethod (N. Otsu, 1979).

2). Character lines are separated from binarized blackboard image using horizontal histogram. The horizontal histogram values take zero, in the case of that, a space is existed between two character lines. Separation is conducted considering this feature.

3). Basic segments are separated from a character line using its vertical histogram. The vertical histogram

values take zero, in the case of that, a space is existed between two nearby characters. Separation is conducted considering this feature.

4). Combined segments are obtained using the adjacent basic segments.

5). Character recognition is conducted for all combined segments using WDIHM(S.Tsuruoka, K.Kurita, T.Harada, F.Kimura and Y.Miyake, 1987).

6). This system calculates evaluation value "*e*" for all combined segments using Eq. (1).

$$e = d + c * \left|\frac{w}{h} - 1\right| * 100 + (g - g_{av} \quad (1)$$

where, "*d*" is dissimilarity(result of character recognition) and weighting factor "*c*" is set as 1.7. "*w*" and "*h*" are the width and the height of each combined segment. "g" and "g_a" are the gap between combined segment and the average value of all gaps, respectively.

7). If more than two combined segments are consecutively included in one basic segment, then combined segment which has smallest evaluation value is selected as a character candidate (Fig. 3).

8). This system extracts keywords from the result of character recognition using keyword dictionary(D.Yoshida, S.Tsuruoka, H.Kawanaka and T.Shinogi, 2006). In this paper, we focus on a "C language" conducted in Mie University, Japan. We use keywords in the index of textbook as keyword dictionary.

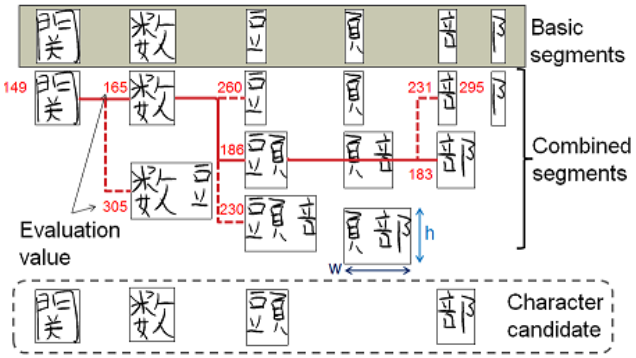


Fig. 3: Character segmentation process

Interactive learning support user interface:

The usability of the previous user interface was not so high, since keyword search cannot be conducted. To improve the usability we propose a new interactive learning support user interface. This system has a keyword search function, which includes automatic keyword indexing by extracting keywords from blackboard lecture scenes (Fig. 4).

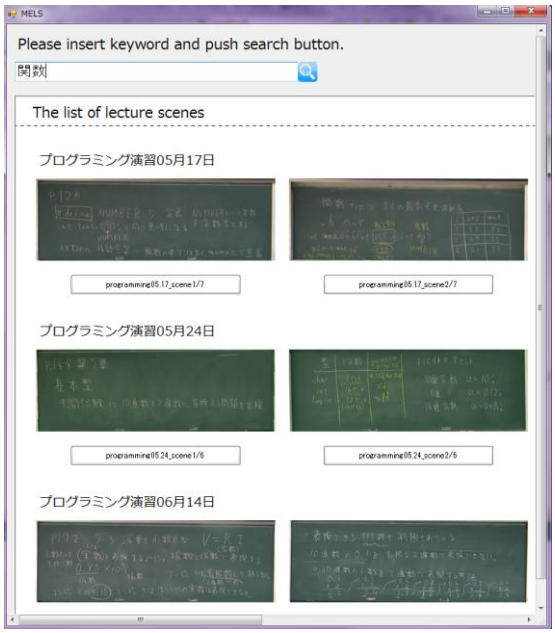


Fig. 4: User interface for keyword search

We add an interactive learning support function which students can learn unknown keyword immediately in watching the lecture scene to use electronic textbook and web search (Fig. 5). The system displays the result of Google search of the keyword in the web search function. Students can watch entire lecture video and lecturer tracking video at the same time (H.Tanaka, H.Kawanaka, T.Sedo, H.Takase and S.Tsuruoka, 2012).

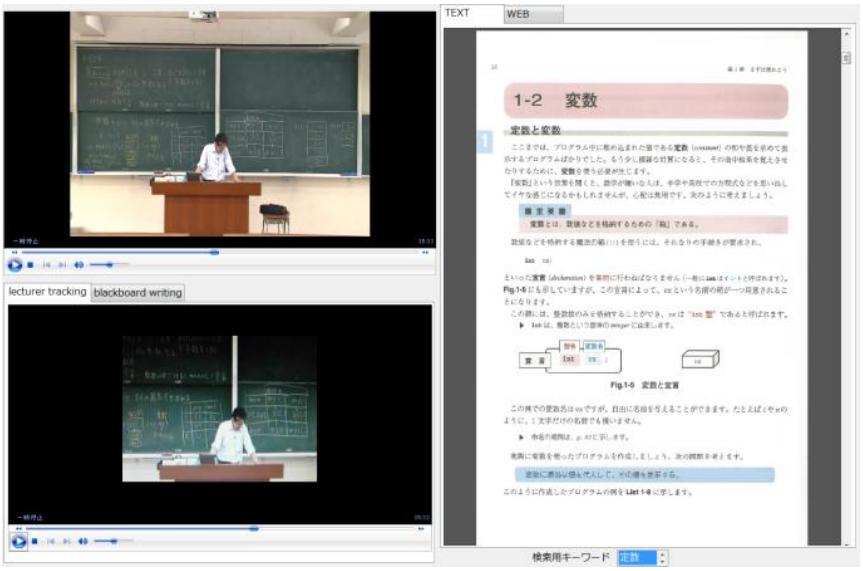


Fig. 5: Interactive leaning support user interface

RESULTS AND DISCUSSION

Character Segmentation and Keyword Extraction:

Character segmentation and keyword extraction experiments were conducted for actual blackboard lecture scenes (60 images) to evaluate the proposed method. The lecture scenes are the writing scene of 10 lecturers, which include 2 to 4 character lines per blackboard image and the number of keyword is 360 words. We adopted Eq. (2) and Eq. (3) to calculate the CSR (character segmentation rate) and KER (keyword extraction rate), respectively.

$$\text{CSR} \quad \frac{correctsegmentedcharacterlineimage}{Thenumberofcharacterlineimage} = *100 \qquad (2)$$

$$\text{KER} \quad \frac{Thenumberofextractedcorrectkeyword}{Thenumberofkeyword} = *100 \qquad (3)$$

Fig. 6 shows a comparison of the experimental results between previous method and proposed method. With the new proposals, character segmentation rate is improved 6.0% (79.1% to 85.1%) for 134 character line images and keyword extraction rate is improved1.4% (78.6% to 80.0%) for 360 keywords.The proposed method improves keyword extraction accuracy due to the significant improvement of character segmentation using the gap between each character (Fig. 7). However, this method is not so effective for segmenting the overlapped characters (Fig. 8).

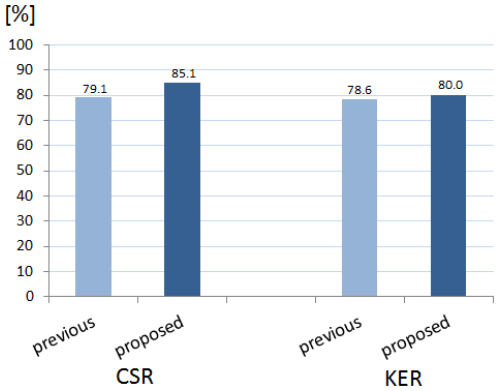


Fig. 6: Results of the character segmentationand keyword extraction experiments

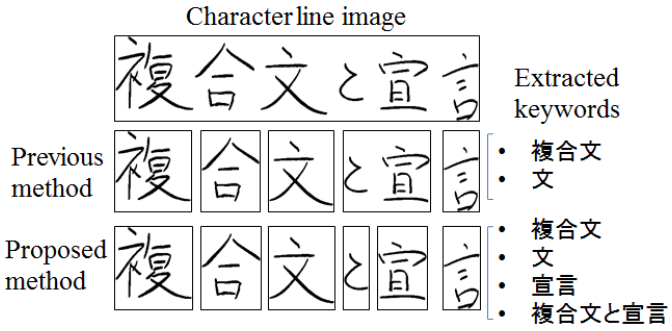


Fig. 7: Improvement of the character segmentation

Fig. 8: Example of the overlapped character

Evaluation of user interface:

The previous interface (search from the list of lecture scene) and proposed interface (with keyword search) were tested to evaluate their performance. 10 university students were used for testing, here students searched desired lecture scenes related to pre-designated keyword. We measured the required time to search these lecture scenes. Fig. 9 illustrates the experimental result of lecture scene search. In the proposed interface, the search time of desired lecture scene reduced to one-ninth of search time of previous interface. According to experiments, proposed interface showed better performance compared to the previous one.

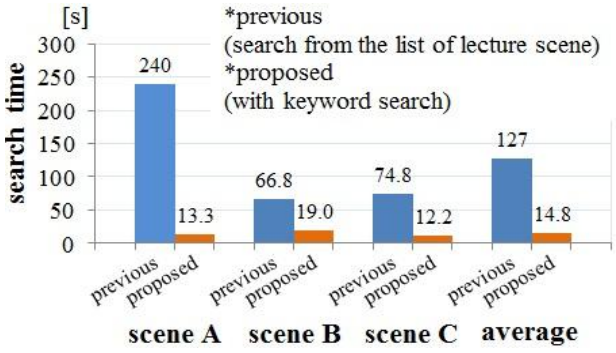


Fig. 9: Experimental results of lecture scene search

Furthermore, we conducted questionnaire for 10 students. The students rate each questionnaire item on a scale of 1 to 5. Here, 5, 4, 3, 2 and 1 means “Strongly agree”, “Agree”, “Neutral”, “Disagree” and “Strongly disagree”, respectively. Table 1 shows the evaluation of the user interface by questionnaire. Here, Q.1 to Q.4 show the questionnaire items about search function of this system. Q.5 shows the questionnaire item about scene separation. Scene separation is conducted using the state recognition of blackboard(S.Okuni, S.Tsuruoka, G.P.Rayat, H.Kawanaka and T.Shinogi, 2007).Q.6 and Q.7 show the questionnaire items about interactive learning support function.According to the table 2, 70% of the students answered “Strongly disagree” to Q1 and 80% answered “Strongly agree” to Q2. This shows that proposed search method shows better usability than previous search method. Although almost of students answered “Strongly agree”, “Agree” or “Neutral” to Q4 and to Q5, a student answered “Strongly disagree”. This student told “Some scene separations are inappropriate, so it took considerable time to find what I wanted to watch sometimes”. The following are the other opinions fromstudents who tested user interface.

- The system is user-intuitive and easy to use.
- The system seems to be useful for student to study.
- The interactive learning support function performes better understanding of the system.

- The electronic textbook suggested by the system was appropriate, however, web page was not appropriate.
- Student want system to display the keyword index of the lecture scene in the scene search.

Table 1: Questionnaire items to evaluate user interface

Q.1 You can search a desired lecture scene easily with previous method (search from the list of lecture scene).
Q.2 You can search a desired lecture scene easily with proposed method (with keyword search).
Q.3 This system has a sufficient search function.
Q.4 You can search a desired lecture scene appropriately.
Q.5 The position of scene separation is appropriately.
Q.6 You can study efficiently using interactive learning support function.
Q.7 Displayed interactive learning support material (electronic textbook or web page) is appropriately.

Table 2: Questionnaire results of 10 students

	5 Stlongly agree	4 Agree	3 Neutral	2 Disagree	1 Strongly disagree
Q1	0	0	1	2	7
Q2	8	2	0	0	0
Q3	1	6	2	1	0
Q4	4	5	0	0	1
Q5	0	5	4	0	1
Q6	6	4	0	0	0
Q7	3	6	1	0	0

Conclusion:

This paper discusses a new character segmentation method forextracting keywords from blackboard images and interactive learning support user interface for developing an e-learning system. According to the experiments the new character segmentation method showed better performance than previous one. As a result, the keyword extraction from blackboard images for developing an e-learning system could be improved. Furthermore, the proposed user interface also showed better performance in the keyword search. The subjective experiment using a questionnaire also showed the better usability of the proposed interactive learning support user interface.

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