DEIM Forum 2011 B7-3

Slide-KWIC Browser: Snippet Generation Based on Semantic Relations and Document Structure for Presentation Slides

Yuanyuan WANG† and Kazutoshi SUMIYA‡

† Graduate School of Human Science and Environment, University of Hyogo

1-1-12 Shinzaike-honcho, Himeji, Hyogo, 670-0092 JAPAN

‡ School of Human Science and Environment, University of Hyogo

1-1-12 Shinzaike-honcho, Himeji, Hyogo, 670-0092 JAPAN

E-mail: † nd09s005@stshse.u-hyogo.ac.jp, ‡ sumiya@shse.u-hyogo.ac.jp

Abstract Currently, presentation contents are useful and valuable to students for e-Learning. However, there is still a lack of support for self-learners browsing through slides containing information that might be irrelevant to their query. We propose a snippet-generation method, and discuss how to present the retrieval results to users by considering what portions of the slides are relevant to a user query, on the basis of the relationships between slides that enable the browsing of slide retrieval at the conceptual level. This method uses the keyword conceptual structure of the semantic relations, and the document structure of the indent levels in the slides. We also present a prototype system and evaluate its effectiveness through experiments.

Keyword Multimedia, E-Learning, Presentation content retrieval, Snippet generation, Semantic relation

1. Introduction

These days, a considerable amount of e-Learning materials, which are often prepared by using teaching materials used in actual classes conducted in universities or other education organizations, is freely shared on websites such as SlideShare[1] and MPMeister[2]. Thus, not only students who missed a lecture or presentation but also those interested in the topic being discussed in the lecture can review it according to their convenience.

A user must formulate a query in the proper manner if he or she wishes to retrieve the required lecture slides on the basis of matching keywords. If the keywords in a query appear repeatedly, many irrelevant slides could be retrieved, and this would make it difficult to obtain an appropriate retrieval result through keyword-based retrieval only. Moreover, one of the important functions necessary for retrieving slides by using the given keywords. For the benefit of users, it is essential that certain keywords are supported to enable the retrieval of important slides. However, retrieving the important slides only on the basis of certain keywords can destroy the implicit relevant information between slides and decrease the relevance of the retrieved slides to the given context, lowering the user's understanding of the information on the slides. Additionally, these methods do not consider the relevant information existing between the slides related to the query; it is impossible to easily obtain successful retrieval results through the concepts represented by a query. Furthermore, some information might be irrelevant to the query in the retrieved slide; then, we find the relevant information to the query as a unit of the retrieved slide, we called it a portion by considering the sentences contain the information in terms of the query on the level of indents in slide text. When a user focuses on one slide, the user might not understand the context of the focused slide in terms of the query by browsing only this one. Therefore, we consider a method ascertains a portion of the focused slide to visualize the relevant information by the portions of other slide as its surrounding context.

In this work, we present a novel snippet-generation method to meet users' requirements can be implemented by (1) identifying the portions of slides that satisfy a user query and (2) generating snippets to present the relevant portions of slides on the basis of the relationships between slides that include what users need to browse. To achieve our goal, we derived a keyword conceptual structure consisting of the semantic relations between keywords extracted from the slide text using the conceptual dictionary WordNet[3]. Additionally, we derived a document structure that the level of indents in the slide text.

We propose Slide-KWIC Browser (see Fig. 1); there are three layers, the basic layer is the focused slide, the high layer is a generalized slide of the focused slide, the low layer is a detailed slide of the focused slide. Then, we

[1] http://www.slideshare.net/
[2] http://www.ricoh.co.jp/mpmeister/
[3] http://wordnet.princeton.edu/

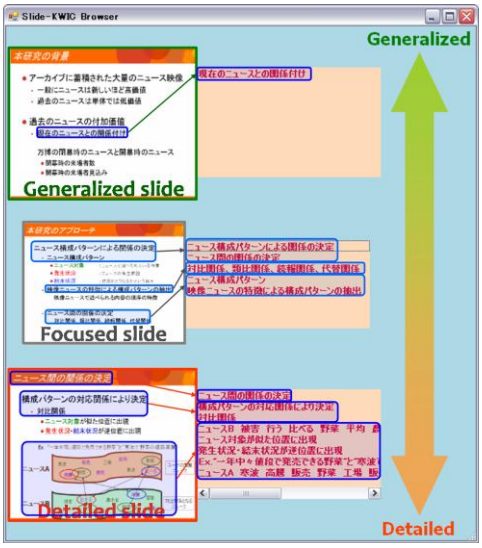

Fig. 1 Screen shot of Slide-KWIC Browser for focused slide

generate a snippet which consists of a portion of the focused slide with the relevant portions of related slides in terms of the query; it can help users understand the focused slide in presentation content easily. As mentioned above, it was then necessary to use the semantic relations and document structure to identify a portion what sentences on the level of indents containing information in terms of the query in the focused slide, along with the relevant portions from other slides, on the basis of the relationships between slides.

As an example, consider a user query "vegetable," whose snippet in slide *x* is shown in Fig. 2. In fact, some presentation slides may be related to other slides in terms of detailed and generalized information. Therefore, we generated snippets of the relevant portions of the retrieved slides on the basis of the relationships between slides. For instance, the explanation provided in slide *y*, "spinach is leafy vegetable" is more likely to be more specific and detailed than the general one provided in slide *x*, "vegetables," as a callout rectangular shape in Fig. 2. Therefore, slide *y* has a *detailed* relationship with slide *x* in terms of "vegetable." In this case, a snippet for slide *x* would look like a portion P_x of slide *x* with a portion P_y of slide *y* related to "vegetable."

The remainder of this paper is organized as follows: The next section reviews of related work. Section 3 explains the keyword conceptual structure and document structure. Thus, we mathematically determine the relationships between slides. Section 4 describes the generation of snippets using the relationships between slides. Section 5 shows a prototype based on our proposed method with several experiments. Finally, Section 6 concludes this paper with further work.

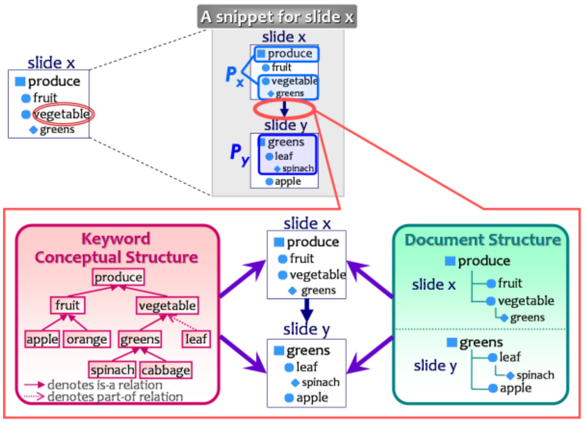

Fig. 2 Snippet of slide using the relationships between slides

2. Related Work

Most of the research related to academic content has been focused on slide retrieval. Yokota et al. [1] proposed a system named Unified Presentation Slide Retrieval by Impression Search Engine (UPRISE) for retrieving a sequence of lecture slides from archives containing a combination of slides and recorded videos. Kobayashi et al. [2] proposed a method based on the use of laser pointer information for retrieving lecture slides by UPRISE. Le et al. [3] proposed a method for extracting important slides by automatically generating digests from recorded presentation videos. Their method extracts important slides from unified content on the basis of the metadata features of a single medium or two heterogeneous media. However, we considered that retrieving only the important slides decreases the relevance of the results of a user query to the given context, and their method cannot be used to browse important slides containing information related to a query. This does not enhance the user's understanding. Therefore, our objectives are accumulating the relevant information between slides in terms of a user query and generating snippets of slides using the relationships between the slides related to the query.

Kushki et al. [4] proposed a novel XML-based system for slide retrieval by analyzing contextual information, such as structural and formatting features, is extracted from the open format XML representation of slides. Our complementary method considers both the structural features of the slides and the semantic relations between keywords in the slide text, and we analyze these two features to determine the relationships between slides. Kitayama et al. [5] proposed a method for extracting slides on the basis of their semantic relationships and roles. This study is similar to ours, in that the researchers have proposed a method for slide retrieval using the relationships between slides. Our method extends them focus on generating snippets on the basis of the relationships between slides.

Parapar et al. [6] proposed a snippet generation method for blog search based on sentence selection, using comments to guide the selection process. We propose a snippet-generation method for slide retrieval based on the relevant portions of slides, and we use the semantic relations and the document structure to detect the relationships between slides. Penin et al. [7] extended existing work on ontology summarization to support the presentation of ontology snippets for semantic web search engines, and the proposed solution leveraged a new semantic similarity measure to generate snippets on the basis of the given query. This ontological method is similar to our method; we focus on the keyword conceptual structure as ontology. In addition, Penin et al. [7] computed the similarity between bags of words to compare sentences and thus generate snippets that displayed query related topics and sentences. However, our snippet-generation for slides that are not semantic web documents, and we determine the relationships between slides using the semantic relations of keywords and document structure, to provide snippets of the portions of slides that are only relevant to the given query.

3. Semantic Relations and Document Structure

3.1. Basic Concept

We consider that semantic relations implicitly exist between keywords in the slide text. In particular, a basis for the most common semantic relations such as an is-a and a part-of relation [8], [9]. "Y is-a X" usually means concept Y is a specialization of concept X and that concept X is a generalization of concept Y. Moreover, "Z is a-part-of X" usually means Z is a meronym of X, and that the whole X has Z as a part. For example, a "fruit" is a generalization of an "apple," an "orange," and many other fruits; in other words, an apple is a fruit (apple is-a fruit). Furthermore, a "pulp" is a part-of "fruit" (pulp is a-part-of fruit). Therefore, we define a keyword conceptual structure as consisting of an is-a or a part-of relation between keywords extracted using WordNet.

We define a document structure as a slide appears in the outline pane, on the basis of indents in the slide text extracted from the Office Open XML. The slide title (1st level indent) is the upper level. The first item of the text is on the 2nd level, and the depth of the subitems increases with the level of indentation (3rd level, 4th level, and so on). Indents outside the text, such as figures or tables, are on the average level of the slide.

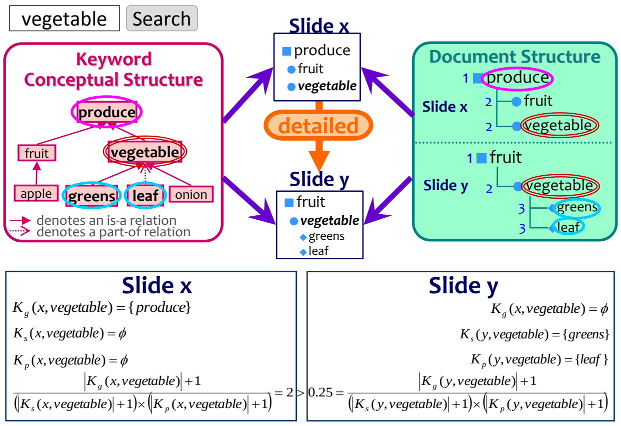

Fig. 3 Example of detailed relationship between slides

3.2. Determination of Relationship Types

We define a focused slide that a slide in question and other slides that have specific relationships as being conceptually related to the focused slide through one of two types of relationships: *detailed* and *generalized*. If a slide has a *detailed* relationship with the other slides, it is called a *detailed* slide. If a slide has a *generalized* relationship with the other slides, it is called a *generalized* slide. Let x be the number of a focused slide and y be the number of the slide that we want to retrieve. Slide x contains keywords k_i, k_j and k_m. The types of relationships are determined for all slides for query keyword q.

3.2.1. Determination of Detailed Relationships

If a slide has more information about a user query than the focused slide, its relationship with the focused slide is a *detailed* one. We explain the determination of *detailed* slides using q that is present in the focused slide x and slide y, which needs to be retrieved. Fig. 3 shows an example of the determination of the *detailed* relationship between slide x and y for a query on the word "vegetable."

When q and other keywords in slide x and y satisfy certain conditions, slide y is determined to be the detailed slide of slide x. This is because q has more specific content in slide y than it does in slide x.

$$K_g(x,q) = \{k_i \mid k_i \in x,\, l(q) \geq l(k_i),\, q\ is-a\ k_i\} \quad (1)$$

$$K_s(x,q) = \{k_j \mid k_j \in x,\, l(q) < l(k_j),\, k_j\ is-a\ q\} \quad (2)$$

$$K_p(x,q) = \{k_m \mid k_m \in x,\, l(q) < l(k_m),\, k_m\ part-of\ q\} \quad (3)$$

Here, $K_g(x,q)$ is a set of keywords can be considered as a general information in terms of q in slide x. In Eq. (1), k_i belongs to $K_g(x,q)$, its level $l(k_i)$ is not lower than $l(q)$ of q in the document structure, and q is-a k_i in the keyword conceptual structure. In our method, the keyword conceptual structure is extracted as a tree-shaped structure. In general, an is-a or a part-of relation between keywords is equivalent to a parent-child relation, and our method may classify an is-a or a part-of as a descendent relation.

$K_s(x,q)$ is a set of keywords can be considered as a specified information in terms of q in slide x. In Eq. (2), k_j belongs to $K_s(x,q)$, its level $l(k_j)$ is lower than $l(q)$ in the document structure, and k_j has an is-a relation with q in the keyword conceptual structure. $K_p(x,q)$ is a set of keywords can be considered as more information in terms of q in slide x. In Eq. (3), k_m belongs to $K_p(x,q)$, its level $l(k_m)$ is lower than $l(q)$ in the document structure, and k_m has a part-of relation with q in the keyword conceptual structure. In general, a detailed information means more specified explanation of a term that a detailed relationship seems to be a mixture of an is-a and a part-of relations.

Based on the above criteria, we compute the ratio of general and detailed content related to q for slide x and y, and compare their ratios using the following formula:

$$\frac{|K_g(x,q)|+1}{(|K_s(x,q)|+1)\times(|K_p(x,q)|+1)} > \frac{|K_g(y,q)|+1}{(|K_s(y,q)|+1)\times(|K_p(y,q)|+1)} \tag{4}$$

where the function $|K_g(x,q)|$ extracts the total number of k_i in $K_g(x,q)$, $|K_s(x,q)|$ and $|K_p(x,q)|$ extracts the total number of k_j and k_m in slide x. $K_g(y,q)$, $K_s(y,q)$, and $K_p(y,q)$ is also a set of keywords in slide y, satisfying the same conditions of $K_g(x,q)$ by Eq. (1), $K_s(x,q)$ by Eq. (2), and $K_p(x,q)$ by Eq. (3). Thus, Eq. (4) can be used to calculate the ratio of $|K_g(x,q)|$ to $|K_s(x,q)|$ and $|K_p(x,q)|$ for slide x and the ratio of $|K_g(y,q)|$ to $|K_s(y,q)|$ and $|K_p(y,q)|$ for slide y. If the ratio calculated for slide x is higher than that calculated for slide y using Eq. (4), slide y is determined to be the detailed slide of slide x with regard to q.

3.2.2. Determination of Generalized Relationships

If a slide contains content about the query in the outline given in a generalized slide, it is described in relation to the focused slide. We explain the determination of generalized slides using q present in the focused slide x and slide y; which needs to be retrieved.

$$\frac{|K_g(x,q)|+1}{(|K_s(x,q)|+1)\times(|K_p(x,q)|+1)} < \frac{|K_g(y,q)|+1}{(|K_s(y,q)|+1)\times(|K_p(y,q)|+1)} \tag{5}$$

When q and other keywords in slide x and y satisfy Eqs. (1), (2), (3), and (5), then slide y is determined to be a generalized slide of slide x. This is because q has more general content in slide y than it does in slide x. Eq. (5) can be used to calculate the ratio of $|K_g(x,q)|$ to $|K_s(x,q)|$ and $|K_p(x,q)|$ for slide x and the ratio of $|K_g(y,q)|$ to $|K_s(y,q)|$ and $|K_p(y,q)|$ for slide y. When the ratio calculated for slide x is lower than that calculated for slide x using Eq. (5), slide y is determined to be the generalized slide of slide x with regard to q. As can be seen, detailed and generalized slides are functionally interchangeable, whereas a focused slide is a generalized slide from the

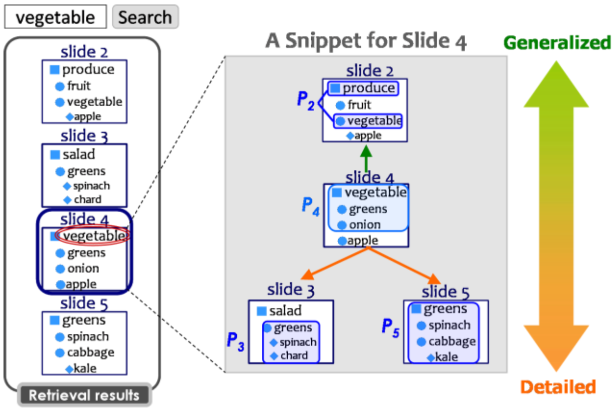

Fig. 4 Example of snippet generation

viewpoint of a detailed slide.

4. Snippet Generation

To generate snippets, we take the relevant portions of the focused slides in terms of a user query using the relationships between slides. For example, a user wants to study slide *4* to further understand “vegetable” in the lecture content about Nutrition. Our method generates a snippet for slide *4* using a portion P_4 includes the sentences from the level of indents in terms of “vegetable” in slide *4*, with a portion P_2 includes the sentences on the level of indents explaining “produce vegetables” in terms of “vegetable” in slide *2*, and a portions P_3, P_5 include the sentences on the level of indents explaining “cabbage and spinach are leafy vegetables,” in terms of “vegetable” in slide 3 and slide 5 (see Fig. 4). In this case, slide *2* has a generalized relationship with slide *4* in terms of “vegetable,” and both slide 3 and slide 5 have a detailed relationship with slide *4* in terms of “vegetable.” When the user browses the snippet for slide *4* that consists of P_4 of slide *4* with P_2, P_3 and P_5 of slide *2*, slide *3* and slide 5, he or she may get more information on “vegetable” in slide *4*, and it enables the user to further his or her understanding easily. Therefore, our method presents snippets containing related portions in terms of a detailed, ordered user query at the conceptual level. This section describes how to generate snippets by the following procedures:

4.1. Identifying the Portions of Retrieved Slides

Our method can retrieve slides related to a user query. However, whether the information contained on the slides is relevant or irrelevant to the query must be determined. Therefore, our method first identifies the portions of the retrieved slides related to the query on the basis of the keyword conceptual structure and document structure. Let x be the number of the retrieved slide containing keywords k_h, k_u and k_v. When the query keyword q and other keywords in slide x satisfy Eqs. (1), (2), (6), (7), and (8), the portion P of slide x is determined to be related to q.

$$K_w(x,q) = \{k_h \mid k_h \in x, l(q) \geq l(k_h), q \ part-of \ k_h\} \quad (6)$$

$$L_g(x,q) = \{s_n \mid s(k_u) \leq d(s_n) \leq s(q), k_u \in K_g(x,q)\} \quad (7)$$

$$L_s(x,q) = \{s_m \mid s(q) \leq d(s_m) \leq s(k_v), k_v \in K_s(x,q)\} \quad (8)$$

$$P = L_g(x,q) \cup L_s(x,q) \quad (9)$$

Here, $K_w(x,q)$ is a set of keywords can be considered as a whole concept in terms of q in slide x. In Eq. (6), k_h belongs to the set of keywords $K_w(x,q)$ in slide x, its level $l(k_h)$ is not lower than $l(q)$ of q in the document structure, and q has a part-of relation with k_h in the keyword conceptual structure. Where the function $L_g(x,q)$ extracts a set of sentences s_n in the slide x such that the levels of the sentences range from the depth of the level containing k_u that q has an is-a or a part-of relation with it, and k_u belongs to $K_g(x,q)$ or $K_w(x,q)$; the extraction is performed using Eq. (1) or Eq.(8). In Eq. (7), $s(q)$ is the sentences from the depth of the levels containing q in slide x, and its depth is not less than the depth $d(s_n)$ of the sentence from the given level; in addition, $s(k_u)$ is the sentences from the depth of the levels containing k_u in slide x and its depth is not greater than the depth $d(s_n)$ of the sentence from the given level. $L_s(x,q)$ extracts a set of s_m in slide x such that the levels of the sentences range from the depth of the level containing k_v has an is-a or a part-of relation with q, that belongs to $K_s(x,q)$ or $K_p(x,q)$; the extraction is performed using Eq. (2) or Eq.(3). In Eq. (8), $s(q)$ is the sentences from the depth of the levels containing q in slide x and its depth is not greater than the depth $d(s_m)$ of the sentence from the given level; in addition, $s(k_v)$ is the sentences from the depth of the levels containing k_v in slide x and its depth $d(s_m)$ is not less than the depth of the sentence from the given level. Thus, Eq. (9) can be used to extract P of slide x and thus combines the sets $L_g(x,q)$ and $L_s(x,q)$.

4.2. Determining the Portions of Related Slides

Our method generates snippets on the basis of the relationships between slides related to a user query. The relevant portions are extracted from slides have relationships with the focused slides in terms of the query.

4.2.1. Determining the Portions of Generalized Slides

When slide x_g is a generalized slide that has a generalized relationship with the retrieved slide x related to the query keyword q, the portion P_g of slide x_g provides the general content of the portion P of the retrieved slide x related to q. Therefore, the portion P_g of the generalized slide x_g is determined using q and the generalized keyword k_u is determined from the retrieved slide x.

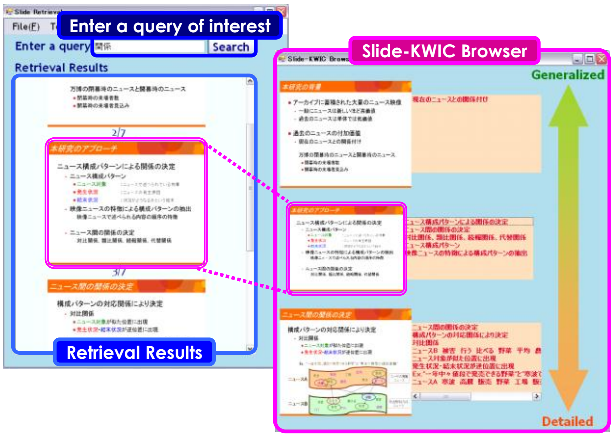

Fig. 5 Screen image of a prototype system

$$P_g = L_g(x_g, k_u) \cup L_g(x_g, q) \quad (10)$$

When q and other keywords in slide x_g satisfy Eqs. (1), (6), (7), and (10), then the portion P_g of the generalized slide x_g is determined. This is because slide x_g contains the general content of q more than slide x does. For slide x_g containing the generalized keyword, k_u is determined from the focused slide x and q. When the respective functions $L_g(x_g,k_u)$ and $L_g(x_g,q)$ are used to extract a set of sentences s_n from levels in that slide and satisfy the same conditions as the function $L_g(x,q)$ by Eq. (7), Eq.(10) can be used to determine the portion P_g of slide x_g that combines the sets $L_g(x_g,k_u)$ and $L_g(x_g\ q)$.

4.2.2. Determining the Portions of Detailed Slides

When slide x_d is a detailed slide that has a detailed relationship with the focused slide x related to the query keyword q, the portion P_d of slide x_d provides specific, detailed information about the portion P of the retrieved slide x related to q. Therefore, we determine the portion P_d of the detailed slide x_d using q, and the specified keyword k_v is determined from the retrieved slide x.

$$P_d = L_s(x_d, q) \cup L_s(x_d, k_v) \quad (11)$$

When q and other keywords in slide x_d satisfy Eqs. (2), (3), (8), and (11), the portion P_d is determined from the detailed slide x_d. This is because the amount of content in slide x_d that is specific to q is greater than that in slide x. For slide x_d containing the specified keyword, k_v is determined from the slide x and q. When the respective functions $L_s(x_d,k_v)$ and $L_s(x_d,q)$ are used to extract a set of sentences s_m from levels in that slide and satisfy the same conditions as the function $L_s(x,q)$ by Eq. (8), then, Eq. (11) can be used to determine P_d of slide x_d that combines the sets $L_g(x_d,q)$ and $L_g(x_d,k_v)$.

Table 1. Comparison results of identifying the portions of slides from academic contents

	Academic contents by our method					Academic contents by the levels contain the given keywords with their AP levels				
	P-W	P-X	P-Y	P-Z	Average	P-W	P-X	P-Y	P-Z	Average
Precision	69.6%	60.4%	57.7%	66.1%	63.5%	52.8%	47.4%	53.8%	56.1%	52.5%
Recall	67.3%	71.2%	64.0%	75.8%	69.5%	64.6%	77.3%	60.8%	87.4%	73.0%
F-measure	0.68	0.66	0.64	0.71	0.67	0.59	0.59	0.57	0.68	0.61

Table 2. Comparison results of identifying the portions of slides from lecture materials

	Lecture materials by our method					Lecture materials by the levels contain the given keywords with their AP levels				
	L-W	L-X	L-Y	L-Z	Average	L-W	L-X	L-Y	L-Z	Average
Precision	71.3%	60.3%	63.4%	69.6%	66.2%	65.3%	50.0%	52.3%	56.8%	56.1%
Recall	53.7%	70.7%	81.9%	82.0%	72.1%	71.5%	85.3%	90.6%	86.1%	83.4%
F-measure	0.61	0.65	0.71	0.75	0.69	0.68	0.63	0.66	0.68	0.67

As mentioned above, our method for generating snippets of the focused slides by relating portions of the generalized, focused, and detailed slides to provide content varies from generalized to detailed content in terms of a user query for specific content.

5. Evaluation

5.1. Prototype System

We developed a Slide-KWIC Browser to support slide retrieval (see Fig. 5) in Microsoft Visual Studio 2008 C#. This prototype implements the retrieval result part, and the Slide-KWIC Browser part. Our system retrieves slides by the user input query. The terms in the slides are extracted using a morphological analyzer *Mecab*[4], which is called by SlothLib[5] [10]. After a user selects the presentation content for studying and enters a query of interest in the textbox and presses the "Search" button, the retrieved slides are presented in the retrieval result part. When the user clicks certain slide as a focused slide, the Slide-KWIC Browser presents a snippet for the focused slide in the other windows. Therefore, the focused slide with its portion that sentences are extracted in a listbox on the center of the Slide-KWIC Browser window, and other related slides with their relevant portions in the listboxes are displayed in the upper side and lower the focused slide.

5.2. Experimental Dataset

In order to achieve our purpose to generate snippets based on the relationships between slides, we prepared a dataset using actual contents: (1) 4 actual academic contents[6] in a session from DEWS2006 and (2) 36 actual lecture materials[7] in 4 lectures from Aoyama Gakuin University. We show and discuss the experimental results in the follow sections.

5.3. Experiment 1: Validity of Identifying the Portions of Slides

Five participants freely captured portions of sentences on the indents of slides and assessed 3 representative keywords from 40 actual contents identified portions of 312 slides. A correct answer was defined as a portion where three or more participants found the sentences of indents in the slides that they had captured. In this study, we evaluated the validity of the rules for identifying the portions of slides in terms of the query keywords by precision and recall using the results obtained by our method and those obtained from participants who gave correct answers. We calculate the precision and recall of portions in each content that explains different topics. Additionally, we compare the portions obtained by our method and the portions of sentences contain the given keywords on the levels with their anteroposterior levels (abbreviated as: AP levels).

The results of the portions of slides are listed in Table 1, Table 2, and they can be explained as follows:

- The average both precision and recall of the lecture materials were higher than the academic contents, we concluded that we used Japanese WordNet [12] does not necessarily contain all concepts about any experimental keyword that because there are some new concepts of word or some new words are used in academic contents.
- The average precision of academic contents or lecture

[4] http://mecab.sourceforge.net/
[5] http://www.dl.kuis.kyoto-u.ac.jp/slothlib/
[6] DBSJ Archives: http://www.dbsj.org/Japanese/Archives/archivesIndex.html

[7] http://homepage3.nifty.com/~terao/lecture/aoyama/lec_aoyama_top.html

Table 3. Results of generating snippets in academic contents

	Academic contents by our method				
	P-W	P-X	P-Y	P-Z	Average
Precision	68.6%	62.8%	62.1%	80.0%	68.4%
Recall	66.0%	67.0%	57.0%	66.7%	64.2%
F-measure	0.67	0.64	0.60	0.73	0.67

materials was low. In particular, P-Y was lowest than others, and according to our method extracted portions numbered much more than those for which participants concurred. We believe one reason that the participants did not consider the slide titles or figures in slides about the given keywords which our method was used.

- By comparing two methods, the average both precision and F-measure of our method were higher than the other method. The method was compared with our method did not extract some portions contain sentences in slides related to the given keywords; meanwhile, some sentences on the AP levels not related to the given keyword were extracted.

From this experiment, we confirmed that our method can extract the appropriate portions of slides using the keyword conceptual structure and the document structure. However, we should enhance our method for extracting the mathematical formulas related to the given keywords. Further, we should consider how to identify the keywords in different levels from the figures or tables that might be improve the performance in this experiment.

5.4. Experiment 2: Validity of Generating Snippets

We showed to the participants 87 snippets that are composed the portions of slides pertaining to the given keywords from the experimental dataset used in Experiment 1. Five participants took part in this experiment; the snippets presented a detailed explanation of the given keywords in the order of the relevant portions in the slides. A correct answer was defined as snippets of the portions of the focused slides with other slides where three or more participants described the snippets for the focused slides are correct. The results in Table 3, 4 note them as follow:

- The average recall of all contents was low here. When our method was used in experiment 1, did not extracted many correct answers contain the sentences in portions were not extracted by our method. We considered snippets depended on identification of the portions of slides. We used Japanese WordNet [12] did not determine a few words have the semantic relations.
- The average precision of all snippets in academic contents or lecture materials was high. The results indicate that our method can generate appropriate snippets of the relevant portions of slides on the basis of the relationships between slides.
- A few snippets by the portions not including detailed information from detailed slides of the focused slides, which the relationships do not exist between them.

Table 4. Results of generating snippets in lecture materials

	Lecture materials by our method				
	L-W	L-X	L-Y	L-Z	Average
Precision	67.3%	69.2%	72.8%	74.7%	71.0%
Recall	63.4%	69.2%	73.2%	66.6%	68.1%
F-measure	0.65	0.69	0.73	0.70	0.70

For this experiment, it can be seen that our method can generate snippets of the relevant portions of slides related via the query by using the slide relationships. The results suggest that we need to improve the algorithm by using the relationships between slides and extracting the relevant portions of slides in terms of the query.

5.5. Experiment 3: Efficacy of Browsing Snippets

We evaluated the efficacy of browsing snippets when users browse slides with their snippets which are presented by our system. We conducted this experiment for 15 participants by using 4 given keywords from an academic content and a lecture material. To evaluate it, we first prepared correct answers that we asked 3 students what slide explains the most detailed information related to each given keyword in each dataset. A correct answer is considered that there were 2 or 3 students find the same slide. Secondly, we provided two retrieval results by each given keyword presenting (a) the retrieved slides only and (b) the generated snippets for the retrieved slides.

Based on providing two retrieval results for other 12 students not taken part in the stage of preparing the correct answers, we just to ask two questions by two steps as follows:

Step 1. Presenting the retrieval results by (a) for users.

Q1: "Do you think which one explains the most detailed information related to the given keyword in the retrieval results? Please give us a reason for it."

Step 2. Presenting the retrieval results by (b) for users.

Q2: "When you browse the snippets for slides were presented in *Q1*, do you change your answer in *Q1*? Please give us a changed or not changed reason."

We analyzed how many answers are correct from each question are shown in Table 5. The vertical column shows how many correct answers for (Ⅰ) well and for (Ⅱ) usefully given by the participants; the horizontal rows show the correct answers in each content given by the

Table 5. Results of the efficacy of browsing snippets

Dataset	(Ⅰ) Browsing slides only	(Ⅱ) Browsing slides with their snippets
Academic content	14/24	21/24
Lecture material	20/24	18/24
Total	34/48	39/48

participants, note the experimental results as follow:

- The total correct answers of (Ⅱ) were more than (Ⅰ). Therefore, we believe that users browse slides with their snippet are useful to grasp the context of the focused slides easily.
- Correct answers of (Ⅱ) were more than (Ⅰ) in academic content, and correct answers of (Ⅱ) in academic content were more than those in lecture material. Then, we confirmed that when users browse slides in academic contents providing expertise with their snippets are more useful than they browse slides in lecture materials providing prior knowledge.
- Correct answers of (Ⅱ) were less than (Ⅰ) in lecture material that provides prior knowledge are easily understand that participants can select many correct slides by (Ⅰ). We proposed Slide-KWIC browser has three layers only that not consider the relevance of the related slides; then, there were two participants have a little confused about snippets for slides lead to this reason. However, in a minority of them, we also confirmed that our Slide-KWIC browser is helpful for users support to browse slides with their snippets.
- Our snippet-generation method on the basis of the relationships between slides. Then, we concluded that there is a few generated snippets have the effect of determining the relationships between slides

For this experiment, it can be seen that our method that browsing slides with their snippets. Additionally, we should enhance our snippet-generating algorithm to generate snippets have different levels of the focused slides that support for users browsing slides with varying levels of knowledge in e-Learning materials.

6. Concluding Remarks

We have proposed Slide-KWIC Browser support for browsing slides with snippets. Our snippet-generation method is used to retrieve desired slides and generate snippets for them on the basis of the relationships between slides with regard to a user query. The type of detailed and generalized relationships is based on the semantic relations between keywords and the document structure of indents in the slide text.

Acknowledgment

This research was supported in part by a Grant-in-Aid for Scientific Research (B)(2) 20300039 from the Ministry of Education, Culture, Sports, Science, and Technology of Japan.

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