# A method for generating presentation slides based on expression styles using document structure

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**Abstract:** A communication environment in which people use presentation slides to exchange and discuss ideas can be created. Presenters, however, must clearly communicate content for audience understanding. Although most slides generated by conventional methods follow structured document summaries (e.g. academic papers), our method has been designed to generate outlines for lecture slides from textbook chapters. We aimed to organise slide layouts from target chapters based on the expression styles of referred slides. Therefore, we analysed level positions of words in the referred slides and arranged words from target chapters to generate slide outlines based on difference in document structure (i.e. text structure, slide structure). To achieve this, we extracted differences between tendency of word appearance in chapters and their slides. This method generated slide outlines by using the expression styles of the corresponding words from the target chapters. In this paper, we have also included an evaluation of our method's effectiveness.

**Keywords:** presentation slide; outline generation; slide-making support; expression style; textbook chapter; document structure; text structure; slide structure; tendency of word appearance; slide layout.

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## 1 Introduction

With the advent of usable presentation tools to create attractive slides, such as Microsoft PowerPoint (2012), Apple Keynote (2012), and OpenOffice Impress (2012), presentations now play a socially important role in promoting understanding in many fields, including business and education. Many university instructors have used web services such as SlideShare (2012) and Apple iTunes U (2012) to store presentation slides that they use in lectures owing to the features for browsing, sharing and reusing slides. Prezi (2012) provides a service for editing, browsing and sharing presentation data. Although useful and powerful support tools for creating slides and web services for sharing slides are widely used, they are generally not effective in generating lecture slides with content that is understood by students; instructors are more effective with preparation of slides of this nature. In particular, lecture slides are often made from textbook chapters (hereafter known as 'chapters') with information to be conveyed by the instructors. It is important, therefore, to focus on how to express the information from textbooks that will appear in slide format. In order to address this problem, we can generate outlines that serve as slide layouts and express typical words from target chapters based on their roles in referred slides, focusing on difference in document structure (i.e. text structure within a chapter, slide structure within a slide). For example, 'vegetable' appears in the body of text in a slide entitled 'Agriculture Market', which relates to sections entitled 'Agriculture Market Analysis', 'Vegetable Production' and 'Vegetable Plants'; it is dispersed within a textbook chapter. 'Vegetable' is the title of another slide that is related solely to the section entitled 'Vegetable Production'.

Our approach creates an editable slide outline producing slides based on typical words. Main points or topics in a logic structure are presented by focusing on a hierarchical representation of the words to help presenters prepare slides easily and efficiently. We explored slide outline creation and found that a word might be expressed differently in various slides. For instance, a word may be the title of one slide or in the body of the text in another for presentation content. We also learned that various styles of presentation slides are typically created from the same document based on different expressions of words. As depicted in Figure 1, a teacher can take a target chapter from a textbook containing lectures to prepare slides by using generated outlines based on expression styles of referred slides. In this paper, we newly defined and extended the meaning of expression styles to position levels of the words arranged in slides from chapters, and we considered the roles of the words in the slides that indicate how the words to be handled in slides, focusing on their hierarchical representation. Therefore, we derived the slide structure by focusing on indention levels in slide text that are often used to help presenters better organise their content. Text structure from chapters was derived from their logical units.

An example is shown in Figure 2. Chapter 2 is the target chapter, and Chapters 2 and 1 have the same text structure; we can extract the expression styles of words in referred slides as Presentation 1 (created based on Chapter 1 and specified by a presenter). We can, therefore, generate outlines for slides from Chapter 2 based on the expression styles of the words in Presentation 1 and an analysis of the differences between tendency of word appearance in Chapter 1 and Presentation 1.

**Figure 1** Conceptual diagram of outlines for lecture slides generated from textbook (see online version for colours)

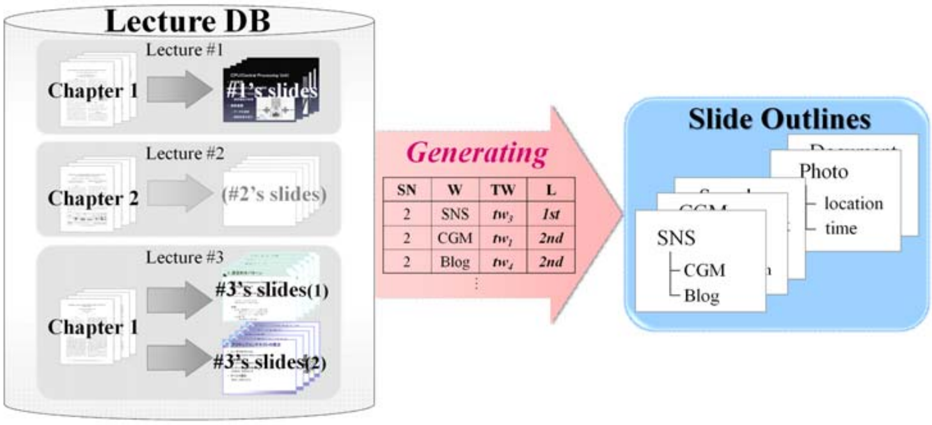
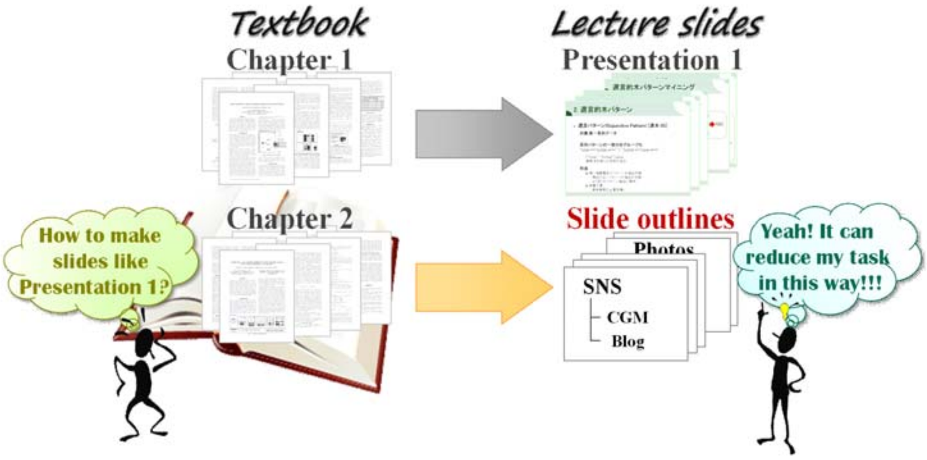



**Figure 2** Outline generation from a target chapter using a chapter and referred slides (see online version for colours)




The remainder of this paper is organised as follows. In the next section, we describe our approach and provide a brief survey of related work. Section 3 contains an explanation of text structure within a chapter and slide structure within a slide; it also explains how to determine tendency of word appearance in chapters and slides. Section 4 describes outline generation for slides based on the expression styles, and Section 5 illustrates our experimental results conducted using a real data set of presentation slides. Finally, Section 6 concludes this paper with suggestions for further work.

## 2 Our approach and related work

### 2.1 Our approach

In this study, the challenge was to develop an application for slide-making based on typical words to help presenters prepare presentation slides easily and efficiently, while reducing their workload. Our goal was to provide a logical slide structure that summarises content and presents the main points or topics. We focused on hierarchical representation of words to present the bare essentials as a basic framework, that is, 'outline'. To clarify, we have proposed a method to generate semi-automatically an editable slide outline that has a number of significant implications. Further, we generated outlines based on level positions of words (e.g. title of a slide, bulleted text) by focusing on the roles of the words and expression styles of the words in referred slides specified by presenters. Our aim was to help presenters reduce the number of tasks associated with creating slides from target chapters.

As our initial motivation for this work, we envisioned an instructor who gives lectures in familiar or similar situations (e.g. students with the same knowledge level or same number of students in a class) and frequently makes presentation files to compose slides in the same expression. We recognised that instructors must know how to create slides and how to present them. Thus, we focused on how to make presentation slides for routine lectures by referring to textbooks. We considered the conventional definition of expression style as the expression of content based on scenario construction in slides (i.e. textbook content). We newly defined and extended the meaning of expression styles based on word alignment to position levels of words in slides extracted from the slide structure, and it is used to express how typical words to be handled in the slides by considering how each word represented in each slide from chapters. Accordingly, we utilised the expression styles of referred slides from previous lectures specified by the instructor to generate slide outlines for the next lecture.

Level positions of words in slides and roles of words were analysed. We defined slide structure based on indents within slides, focusing on titles and bulleted text in the slides. As mentioned above, expression styles were extracted from level positions of words in the referred slides. Two main features that we recognised as particularly helpful for generating slide outlines and arranging corresponding words from target chapters based on difference in document structure (i.e. text structure, slide structure) are as follows:

- When a word is dispersed throughout all sections of a chapter, it is used generally in the chapter; when a word occurs frequently in a certain section of a textbook chapter, it is associated with a specified description in the chapter.
- When a word appears in the slide title of a slide or in lines that are less indented, it is a topic of the slide; and when a word appears in the body of the text on a slide, it is used to explain the topic of that slide.

These two features are particularly helpful for concisely conveying information in slides from textbook chapters by characterising the differences between the tendency of word appearance in chapters and their associated slides.

In this paper, we theorised that a presenter could prepare presentation slides for each lecture from chapters in a textbook by arranging words in slides according to the same expressions of words in referred slides created from chapters specified by the presenter.

Hence, we made a model to generate outlines for arranging the corresponding words from a target chapter in slides based on the expression styles of the words in referred slides; corresponding words from the target chapter were analysed according to differences between the tendency of word appearance in chapters and slides based on document structure (i.e. text structure, slide structure) in the same domain. Finally, we attempted to achieve our goal to generate outlines for slides in an experiment conducted with a real data set.

### *2.2 Related work*

Most of the research related to slide-making support has focused on slide generation. Mathivanan et al. (2009), Beamer and Girju (2009), Miyamoto et al.(2006) and Yoshiaki et al. (2003) proposed a system for generating slides from academic papers. Their method summarises and extracts information from an academic paper by means of tf-idf term weighting, and assigns sentences, figures and tables in slides by identifying important phrases for bullets in order to generate slides. Shibata and Kurohashi (2005) converted documents to slides by parsing their discourse structure and representing the resulting tree in an outline format. In our view, however, conventional methods that focus only on a structured summary of documents ignore how to express words in the slides. Our method, therefore, focuses on the roles of words represented in slides and generates outlines based on the expression styles of words drawn from referred slides specified by presenters.

Kan (2007) proposed a system called SlideSeer for the discovery, alignment, and presentation of documents and slide pairs. This system modifies the maximum similarity in alignment to favour monotonic alignments, and it incorporates a classifier to handle slides that should not be aligned. Hayama et al. (2005) proposed a method for aligning academic papers and slides based on Jing's method, which uses a Hidden Markov Model (HMM). These studies are similar to ours for analysing information that is common to documents and their slides. Our approach, however, focuses not only on the information that is in common, but also on word appearance tendencies that differ between documents and their slides.

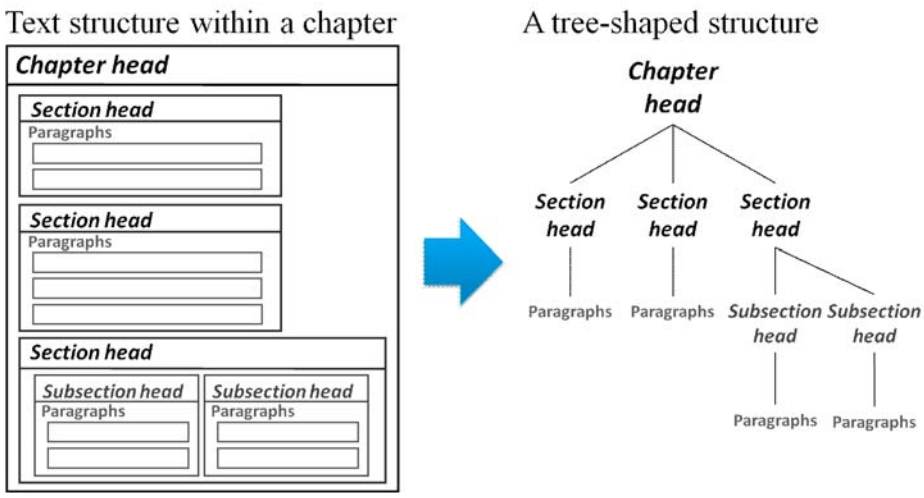
Kurohashi et al. (1997) detected the importance of a word in a document based on its location with the highest density. Yokota et al. (2006) proposed a system called Unified Presentation Slide Retrieval by Impression Search Engine (UPRISE) that can retrieve important information in slides. These studies are similar to ours in terms of the retrieval of characteristic information in documents and slides. However, they focus on important information, while our method considers the differences between text structures within documents and slide structures within slides. Our goal was to analyse the differences between the tendency of word appearance in documents and their associated slides.

From the viewpoint of reusing slides, Sharmin et al. (2012) and Mejova et al. (2011) proposed a system for composing presentation slides from existing ones and modifying them for specific events, such as lectures and conferences. We share a common point in using existing presentation slides to create new ones; however, their studies focused on how to support reuse of existing presentation slides by identifying the similar versions of content. Since the problem associated with providing adequate support for the organisation of slide components has been addressed; Watanabe et al. (2011) and Hanaue and Watanabe (2010) have focused on semantic relationships among slide components for a presentation strategy. Other approaches to presentation composition have included outline matching (Bergman et al., 2010), topic clustering (Spicer and Kalliher, 2009) and hierarchical organisation (Bederson and Hollan, 1994). These approaches are similar to ours in that they help presenters to better organise their slide contents. Our goal, however, is to support presenters in their slide preparation with semi-automatically generated slide outlines based on expressions of words in existing slides.

## 3 Determination of tendency of word appearance

For exploring difference in document structure (i.e. text structure, slide structure), we determined tendency of word appearance by calculating the dispersion and concentration of words within the text structure of a chapter and determining the generalised and detailed information of words within the slide structure of a slide. We defined the text structure of a chapter in terms of its logical units, or sections, which in turn consists of section heads and paragraphs (or subsections, which in turn consist of subsection heads and paragraphs). In our method, the text structure is extracted as a tree-shaped structure (hereafter 'tree'), consisting of the chapter head as a root node and paragraphs as leaf nodes. In addition, a parent–child relationship symbolises the relationship between the chapter head and section head, section and subsection heads, and subsection heads and paragraphs (see Figure 3).

**Figure 3** Example of a tree-shaped structure of text structure within a chapter (see online version for colours)




The content of a presentation includes a number of slides that have structured text information. We defined the slide structure from slides appearing in the outline pane (Russell, 2007), based on the indentions in the slide. The slide title is the first level. The first item of text within the body of a slide is considered to be the second level, and the depth of the sub-items increases with indention level (third level, fourth level, etc.). Objects that are outside of the text, such as figures or tables, are considered to be at the same indention level as the text in which they appear.

### *3.1 Determination of tendency of word appearance in a chapter*

If a word is dispersed in a chapter, the tendency of word appearance of this word is deemed dispersion; it belongs to $W_{d_{ch}}$. In contrast, if a word appears as centred in a chapter, the tendency of word appearance of this word is deemed concentration; it belongs to $W_{c_{ch}}$. We explain the determination of $W_{d_{ch}}$ and $W_{c_{ch}}$ using a word *q*, and we calculate the degree of dispersion and concentration of *q* in the chapter *ch*. When *q* is dispersed at a high degree, *q* is determined to belong to $W_{d_{ch}}$; when *q* is centred at a high degree, *q* is determined to belong to $W_{c_{ch}}$.

$$W_{d_{ch}} = \left\{ q \mid min\left( \frac{\sum_{i=1}^{n} dist(s_1, q_i)}{n}, \frac{\sum_{i=1}^{n} dist(s_2, q_i)}{n}, \ldots, \frac{\sum_{i=1}^{n} dist(s_j, q_i)}{n}, \frac{\sum_{i=1}^{n} dist(s_m, q_i)}{n} \right) > \alpha \right\} \tag{1}$$

$$W_{c_{ch}} = \left\{ q \mid min\left( \frac{n}{\sum_{i=1}^{n} dist(s_1, q_i)}, \frac{n}{\sum_{i=1}^{n} dist(s_2, q_i)}, \ldots, \frac{n}{\sum_{i=1}^{n} dist(s_j, q_i)}, \frac{n}{\sum_{i=1}^{n} dist(s_m, q_i)} \right) > \alpha \right\} \tag{2}$$

where $q_i$ is the *i*-th word *q*, and $s_j$ is the *j*-th section in a chapter *ch*. For deriving $W_{d_{ch}}$ and $W_{c_{ch}}$, we calculated the degree of dispersion and concentration of *q* based on the standard deviation concept. In equations (1) and (2), the function *dist* calculates the distance between $q_i$ and $s_j$; that is, a number indicates how many sections there are between a section that contains $q_i$ and $s_j$. In our method, the section $s_j$ was the standard for measuring how many sections there were between the same word *q* and its appearance in the chapter *ch*. *n* is the number of times that *q* appears in *ch*, and *m* is the number of sections in *ch*. When $q_i$ appears in $s_j$, the distance between them is one (1). The formula in equation (1) or equation (2) that returns the minimum value of *q* is extracted using the function *min* because there are unknown expectations. Thus, the highest degree of expectation is obtained for a position in the section with the lowest degrees of dispersion or concentration. When the minimum value is high in equation (1) or equation (2), it is highly possible that $q$ will appear dispersed or centred in $ch$. $W_{d_{ch}}$ or $W_{c_{ch}}$ represents a bag of words in the chapter; if the formula is greater than a threshold $\alpha$ in equation (1), the tendency of word appearance of $q$ is determined to be dispersed in $ch$, and $q$ belongs to $W_{d_{ch}}$. If the formula is greater than a threshold $\alpha$ in equation (2), the tendency of word appearance of $q$ is then determined to be centred in a range in $ch$, and $q$ belongs to $W_{c_{ch}}$.

## 3.2 *Determination of tendency of word appearance in slides*

If a slide has more information in terms of a given word contained in a prior slide in a presentation file, the tendency appearance of this word becomes upper, and this word belongs $W_{u_{x,y}}$. In contrast, if a slide has generalised information in terms of a given word contained in a prior slide in the presentation file, the tendency appearance of this word becomes lower, and this word belongs to $W_{l_{x,y}}$. We have explained the determination of $W_{u_{x,y}}$ and $W_{l_{x,y}}$ using a word $q$, which is present in slides $x$ and $y$. When $q$ and the other words in slides $x$ and $y$ satisfy certain conditions, $q$ is determined to belong to $W_{u_{x,y}}$ or $W_{l_{x,y}}$.

$$K(x,q) = \{k \mid k \in x, l(x,q) < l(x,k)\} \tag{3}$$

Here, $K(x,q)$ is a bag of words that can be considered to provide an explanation in terms of $q$ in slide $x$. $l(x,q)$ is a function that returns the indent level of $q$ in slide $x$. When $q$ appears frequently in slide $x$, $l(x,q)$ will return the lowest possible value (i.e. the uppermost level at which $q$ occurs in slide $x$). This because we consider that when $q$ appears in an upper level, all the other levels in which $q$ appears in the body of that slide are explanatory points related to a deeper occurrence of $q$. The word $k$ is included in the levels that have a hierarchical relationship with the level of $q$, and $k$ belongs to the bag of words $K(x,q)$ in slide $x$. $l(x,k)$ is greater than $l(x,q)$, in that $k$ is a child of $q$ in the slide structure. When $k$ is not present in slide $x$, $K(x,q)$ will be empty.

Based on the above criteria, we computed the number of words related to $q$ for slides $x$ and $y$ and compared their numbers using the following formulas:

$$W_{u_{x,y}} = \{q \mid |K(x,q)| < |K(y,q)|\} \tag{4}$$

$$W_{l_{x,y}} = \{q \mid |K(x,q)| > |K(y,q)|\} \tag{5}$$

where the function $|K(x,q)|$ extracts the total number of $k$, which belongs to $K(x,q)$ in slide $x$. $K(y,q)$ is also a bag of words in slide $y$, and the words satisfy the same conditions as $K(x,q)$ in equations (4) and (5). Thus, equations (4) and (5) can be used to count the number of words in $K(x,q)$ and $K(y,q)$, for slides $x$ and $y$, respectively. Furthermore, $W_{u_{x,y}}$ and $W_{l_{x,y}}$ represent bags of words in slides $x$ and $y$. If the number count for slide $x$ is lower than that for slide $y$ in equation (4), the word appearance tendency of $q$ is determined to become upper in slides *x* and *y*, and *q* belongs to $W_{u_{x,y}}$. If the number count for slide *x* is greater than that for slide *y* in equation (5), the word appearance tendency of *q* is then determined to become lower in slides *x* and *y*, and *q* belongs to $W_{l_{x,y}}$.

**Table 1** Patterns in the differences of tendency of word appearance

| *Patterns* | *Tendency of word appearance* | |
|---|---|---|
| | *In a chapter* | *In slides* |
| $tw_1$ | Dispersion | Upper |
| $tw_2$ | Dispersion | Lower |
| $tw_3$ | Concentration | Upper |
| $tw_4$ | Concentration | Lower |

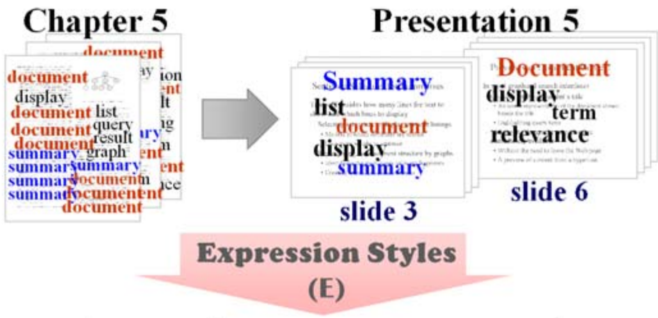
## *3.3 Patterns of tendency of word appearance*

Four patterns have been identified to explain the difference between the appearance tendency of a word *q* in the chapter and slides (Table 1). Explanations for each pattern follow.

- $tw_1$: $q \in W_{d_{ch}} \cap W_{u_{x,y}}$; the tendency of word appearance of *q* in the chapter is dispersion and the tendency of word appearance of *q* in the slides becomes upper.
- $tw_2$: $q \in W_{d_{ch}} \cap W_{l_{x,y}}$; the tendency of word appearance of *q* in the chapter is dispersion and the tendency of word appearance of *q* in the slides becomes lower.
- $tw_3$: $q \in W_{c_{ch}} \cap W_{u_{x,y}}$; the tendency of word appearance of *q* in the chapter is concentration and the tendency of word appearance of *q* in the slides becomes upper.
- $tw_4$: $q \in W_{c_{ch}} \cap W_{l_{x,y}}$; the tendency of word appearance of *q* in the chapter is concentration and the tendency of word appearance of *q* in the slides becomes lower.

Based on the above, we can determine which words should be described in the chapter and the corresponding slides. Further, we can regulate how they are described. In addition, the patterns of the tendency of word appearance provide an indication of the level of explanation needed for words appearing in slides, and whether these words appear dispersed in multiple sections or concentrated in a specified portion of the chapter. In the example shown in Figure 4, ‘document’ is dispersed in all sections in Chapter 5, but it is also a title for slide 6 in Presentation 5. When this word is dispersed in the chapter, it assumes an upper position in the slides as $tw_1$. Slide 6 delves into the topic of ‘document’ in detail and summarises the information regarding its appearance in all sections of Chapter 5. On the other hand, ‘summary’ repeatedly appears in a certain section and slide 3 includes this word as its title (Presentation 5). When the tendency of word appearance of ‘summary’ is concentration in the chapter, it assumes an upper position in slides as $tw_3$. Slide 3 offers specialised information regarding ‘summary’ and refers to a concentrated section from Chapter 5.

**Figure 4** Example of expression styles (see online version for colours)




| Slide No. (SN) | Word (W) | Tendency of Word Appearance (TW) | Level (L) |
|---|---|---|---|
| 3 | summary | $tw_3$ | *1st* |
| 3 | document | $tw_1$ | *3rd* |
| 3 | display | $tw_4$ | *2nd* |

⋮

## 4 Outline generation

### 4.1 Extraction of expression styles

To generate outlines for slides, a slide layout is used; it consists of words based on expression styles by using presentation slides made from chapters in textbooks and specified by presenters. Therefore, we have defined the expression style *E* to denote tendencies of word appearance *TW* of each word that belongs to *W*, and the expression of presentation is represented by the level positions *L* of each word in *W* that belongs to a corresponding slide in *SN*. They refer to a table is shown in Figure 4.

$$E = (SN, W, TW, L) \tag{6}$$

$$W = \{q \mid q \in TW\} \tag{7}$$

$$TW = \{tw_1, tw_2, tw_3, tw_4\} \tag{8}$$

Here, *E* can be considered as a database with four indexes: *SN*, *W*, *TW* and *L* in equation (1). *SN* denotes the slide number in a presentation. In equations (7) and (8), *W* is a set of words that belong to *TW*, and *TW* is a set of appearance tendencies of words in chapters and their corresponding slides illustrate all four patterns (Section 3.3). *L* denotes the level positions of the words in slides via slide structure. For this study, we extracted expression styles to understand what words used in slides were from chapters, and how about their expressions in slides.

### 4.2 Extraction of corresponding words

For this study, we considered texts from textbook chapters with text structures similar to trees (Figure 3, preface of Section 3). Our definition of a subtree is a tree consisting of a node (section head or subsection head) but not a root node (chapter head) and all of its descendants (subsection head or paragraphs) in a tree $T_A$ ($T_B$) of text structure within a referred chapter $A$ (a target chapter $B$). Therefore, we extracted a set of subtrees of $T_A$ and a set of subtrees of $T_B$. When a word $z$ belonged to root nodes of respective subtrees belonging to $T_A$ and a word $z'$ belonged to root nodes of respective subtrees belonging to $T_B$, consistency among them caused us to determine that $z'$ in $B$ corresponds to $z$ in $A$. We have defined a set of subtrees as belonging to $PT(T_A(z))$, and their respective root nodes contained $z$ and $PT(T_A(z))$, which belonged to subtrees of $T_A$. A set of subtrees belonging to $PT(T_B(z'))$ had root nodes that contained $z'$ and $PT(T_B(z'))$, which belonged to subtrees of $T_B$. Then, we extracted $z'$ in $B$ by matching $PT(T_A(z))$ and $PT(T_B(z'))$ as part of a structure-matching method (Madhavan et al., 2001). Words such as $z$ in $T_A$ and $z'$ in $T_B$ were not the same, and the structure-matching method helped identify non-linguistic matches and differentiate between seemingly identical structures in different contexts.

For each word, there were many words in the subtrees $PT(T_A(z))$ of $T_A$ and $PT(T_B(z'))$ of $T_B$ to be compared, and the number of the same structures in the subtrees belonging to $PT(T_A(z))$ and $PT(T_B(z'))$ will be larger. Based on the structure-matching method, we extracted a pair $C$ of $z$ in $A$ and $z'$ in $B$ for the following formula:

$$C = \left\{ (z, z') \middle| \frac{1}{2} \left( \frac{sum\left(PT\left(T_A(z)\right), PT\left(T_B(z')\right)\right)}{N_A} + \frac{sum\left(PT\left(T_A(z)\right), PT\left(T_B(z')\right)\right)}{N_B} \right) > \beta, z \in W \right\} \tag{9}$$

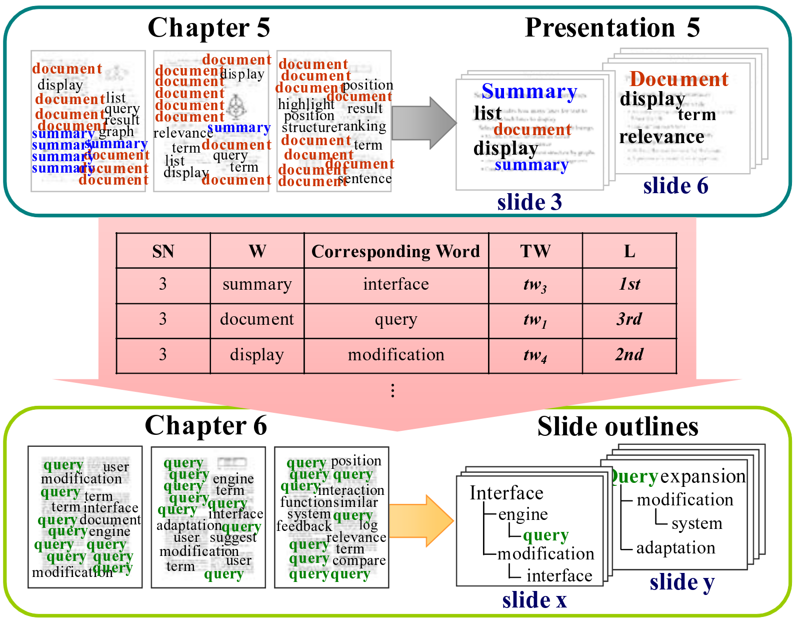
where the function *sum* extracts the total number of the same structures in the subtrees belonging to $PT(T_A(z))$ and $PT(T_B(z'))$. $N_A$ is the total number of the subtrees belonging to $PT(T_A(z))$, and their respective root nodes contain $z$ in $T_A$. $N_B$ is the total number of subtrees belonging to $PT(T_B(z'))$, and their respective root nodes contain $z'$ in $T_B$. We calculated the similarity of $PT(T_A(z))$ and $PT(T_B(z'))$ with the above formula. If the formula was greater than a threshold $\beta$ so that $PT(T_A(z))$ and $PT(T_B(z'))$ were similar, $z'$ was determined to be the corresponding word of $z$. Thus, $z'$ was the candidate word for using the expression styles of $z$ in $A$, and we extracted it as appropriate based on word appearance tendencies of $z'$ in $B$, as compared to the same tendencies in $z'$ and $z$. Finally, we are able to generate outlines for slides by using the expression style of $z'$ in the same expression style as $z$, according to equations (6)–(8). In this way, the number of outlines was determined to be the same as the number of referred slides, and outlines were arranged in the same order as the referred slides.

### *4.3 Generation of outlines for slides*

Presentations consist of slides that rely on a combination of words and images to drive home a point. The way these elements are combined creates the design layout, which is crucial to making slides understandable and memorable. In this paper, outlines were used to design different slide layouts to communicate key points from chapters in lectures. We considered key points as the roles of words from the chapters expressed in slides, and we focused on hierarchical representation of the words, considering the difference in document structure (i.e. text structure, slide structure) that we focused on the word appearance tendencies in chapters so that their slides could be extracted by our proposed method. Therefore, we created slide outlines constructed of different layouts to express words in slides as specified by a presenter (referred slides). Based on the expression styles drawn from referred slides, we can generate outlines for slides from a target textbook chapter by extracting the words from the chapter that correspond to the words in the referred chapter. Therefore, we can semi-automatically generate editable outlines for slides from the target chapter; we simply generate outlines according to the referred slides in the same order and with the same number of slides as the referred slides. In this paper, our generated outlines for making slides focused on hierarchical representation of words to organise the content. Thus, presenters can arrange selected outlines to make a presentation file.

For example, a presenter wants to prepare presentation slides for a lecture regarding Chapter 6 in a textbook. Our method generates outlines for slides for Chapter 6, referring to slides in Presentation 5 from Chapter 5 (Figure 5). In Chapter 5, the word ‘document’ appears in all sections. The word also appears in the title of slide 6 in Presentation 5, so the expression of ‘document’ in slide 6 is title (1st level). In Chapter 6, the word ‘query’ appears in all sections that corresponds to ‘document’ in Chapter 5. The outline for slide *y* generated from Chapter 6 shows that ‘query’ appears in the title of slide *y*, which explains ‘query expansion’. ‘Query’ in slide *y* has the same expression style as ‘document’ in slide 6. When the presenter creates slides referring to the outlines, such as slide *y*, the information for ‘query’ in slide *y* is constructed in the same way as for the level position of ‘document’ in slide 6. It is based on the same expression style by arranging the words to express ‘query’ in the title of slide *y*. The generated outlines can be used to create slide layouts that construct words according to the same roles of the words in the referred slides, and the outlines then enable the presenter to make slides easily.

**Figure 5** Example of outline generation (see online version for colours)



## 5 Evaluation

### 5.1 Implementation

Based on the method described above, we built a tool to support outline generation, using Microsoft Visual Studio 2010 C#. The tool has three stages: analysis, determination and generation. In the analysis stage, we analyse the features of a slide and a chapter. The slide structure and information on the indent level of words are constructed by using Office Open XML files from PowerPoint in Microsoft Office 2007. (In our implementation, we developed a PowerPoint parser, but parsers for Keynote, Open Office Impress, and so on can also be developed. Therefore, we can also use content made by other presentation formats). The text structure of a chapter and information on logic units is constructed using its original LaTeX file. When the chapter is a PDF file, we should convert PDF files into XML files using pdftohtml (2012). The words in the slides can be extracted using the morphological analysers MeCab (2012) and SlothLib (2012) (Ohshima et al., 2007).

In the determination stage, all expression styles of words in referred slides are extracted based on slide structure, and the patterns of word appearance tendency in chapters and their slides are extracted based on the text structure and the slide structure. Corresponding words from a target chapter can be extracted based on tendency of word appearance in that chapter and the referred chapter by matching subtrees with respective root nodes containing the words in the text structures of the target chapter and the referred chapter. Thus, in the generation stage, slide outlines are generated by arranging the corresponding words from the target chapter based on the expression styles of the words in the referred slides specified by a user.

After a user selects the chapter from a textbook for preparing presentation slides, he/she specifies a presentation file from a chapter in the same textbook for reference. The prototype tool has a function to generate slide outlines as layout structures based on Office Open XML Formats in PowerPoint 2007.

### 5.2 Data set

The aim of this evaluation was to verify whether our proposed method is useful for slide outline generation. We first prepared two presentation data sets from a textbook called *Search User Interfaces* (Hearst, 2009):

- Data set 1: $S_{A_1}$ from Chapter $A$ and $S_{B_1}$ from Chapter $B$ were made by the same person ($P_1$).
- Data set 2: $S_{A_2}$ from Chapter $A$ and $S_{B_2}$ from Chapter $B$ were made by the same person ($P_2$).

Because $P_1$ and $P_2$ are characterised by single authorship, we assumed that words in $S_{A_1}$ and $S_{B_1}$ had the same expression styles in data set 1; the words in $S_{A_2}$ and $S_{B_2}$ had the same expression styles in data set 2, and $A$ and $B$ had the same text structure in the same textbook. $S_{A_1}$ and $S_{B_1}$ each contain ten separate slides, not counting the cover slide in data set 1; $S_{A_2}$ contains eleven slides, and $S_{B_2}$ contains ten slides (data set 2). We used *A* and $S_{A_1}$, $S_{A_2}$ to generate respective outlines for presentation files $O_1$, $O_2$ from *B* based on our method using different expression styles of slides. $S_{A_1}$ and $S_{A_2}$ are called referred slides; the respective slides in $S_{B_1}$ and $S_{B_2}$ serve as correct answers regardless of whether the hierarchical representation of the words in the respective outlines generated from *B* are correct or not.

## 5.3 Validity of generating outlines

We generated ten outlines in $O_1$ from *B* in the same order and with the same number of slides as $S_{A_1}$ and eleven outlines in $O_2$ from *B* in the same order with the same number of slides as $S_{A_2}$. We extracted the corresponding words from *B* and arranged them in slide outlines based on the expression styles of the words in $S_{A_1}$ and $S_{A_2}$, respectively. Finally, we compared the generated slide outlines in $O_1$ and $O_2$ with the respective correct answers in $S_{B_1}$'s slides and $S_{B_2}$'s slides (see Figures 6 and 7).

**Figure 6** Generated slide outlines in $O_1$ compared with slides in $S_{B_1}$ (see online version for colours)

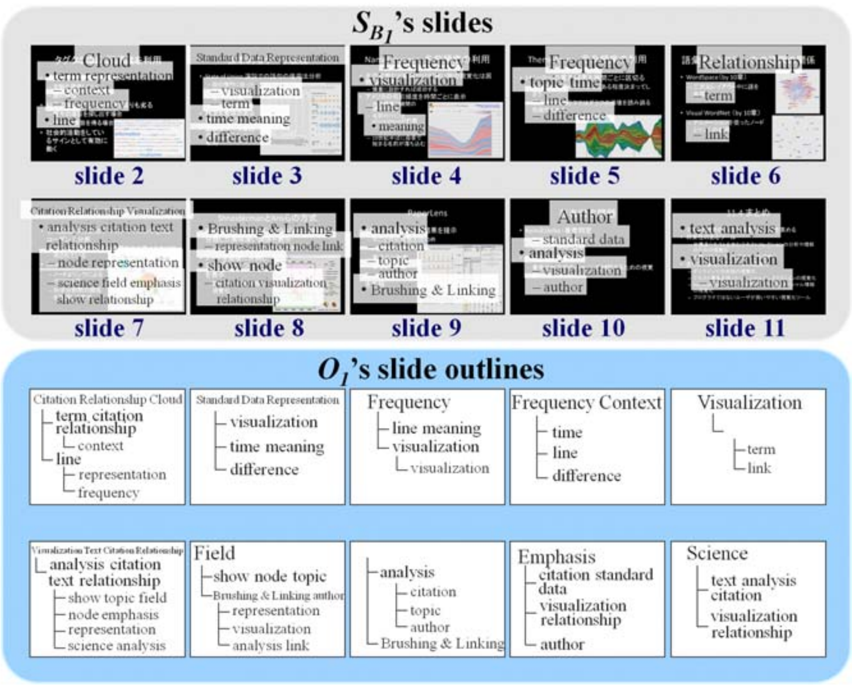
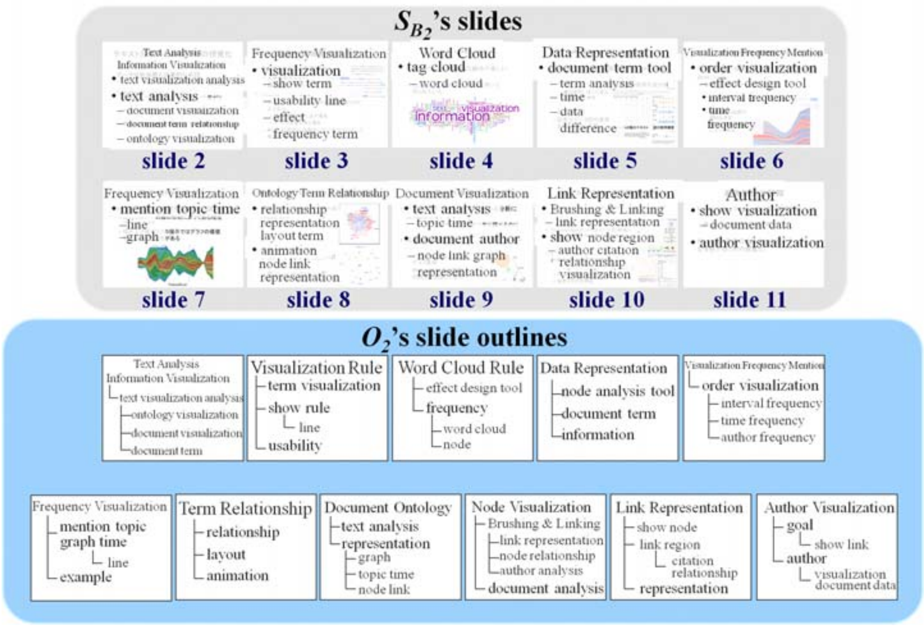


**Figure 7** Generated slide outlines in $O_2$ compared with slides in $S_{B_2}$ (see online version for colours)




For evaluating the generated outlines, we conducted an evaluation based on two aspects:

(a) Measuring the coverage of the words in the generated outlines in $O_1$ and $O_2$ that also appear in $S_{B_1}$ and $S_{B_2}$, respectively. In this way, we calculated the coverage as a 'recall' of the words in generated outlines without assessing slide structure.

(b) Measuring the accuracy of structures in the generated outlines in $O_1$ and $O_2$ by comparing them with $S_{B_1}$ and $S_{B_2}$ based on the hierarchical relationships between two words in the generated outlines. In this way, we calculated the accuracy of structures to evaluate whether the generated outlines in $O_1$ and $O_2$ maintained them as they were in $S_{B_1}$ and $S_{B_2}$, respectively.

In the experimental results of our evaluation, (a) the coverage of the extracted words in $O_1$ reached 33.8% (25/74); in $O_2$, coverage reached 37.8% (31/82). The average for these was 35.8%. (b) The accuracy of the structures in $O_1$ was 42.3% (254/25*24); for $O_2$, accuracy was 44.8% (417/31*30). The average accuracy for both structures was 43.6%. The results of (a) indicate that presenters using the method proposed in this study can extract corresponding words by a conventional method (structure-matching method). However, sometimes we extracted words that corresponded to multiple words in textbook chapters, and only a small number of the extracted words were correct. In addition, we considered the figure captions for determining the words in the chapters. $S_{A_1}$ and $S_{B_1}$, as well as $S_{A_2}$ and $S_{B_2}$, were written by the same person; several words from these files appear in related slides and in captions of figures included in the chapters. Such variables contributed to a lower rate of coverage for responses.

Experimental results of (b) showed that our proposed method is effective in arranging words in generated outlines based on their expression styles. The rate of accuracy for the structures in generated outlines was low due to the fact that it was dependent on the small number of the extracted corresponding words in (a). Using our method, we determined that the hierarchical relationships between some words in $O_1$ and $O_2$ were not in consistency with those in $S_{B_1}$ and $S_{B_2}$. Figure 8 presents an example of adequate results; an outline in $O_1$ was generated from *B*. At the sentence level, the words 'citation', 'topic' and 'author' appear at the third level, and 'analysis' and 'Brushing & Linking' at the second level in the body of a slide as correct answers in $S_{B_1}$ made by $P_1$. Our method arranged the corresponding words 'citation', 'topic' and 'author' from *B* at the third level. Further, 'analysis' and 'Brushing & Linking' from *B* appeared at the second level in the body of the generated outline and in $S_{B_1}$. The hierarchical relationships of these words were the same in $S_{B_1}$'s slide and in the generated outline in $O_1$.

**Figure 8** Adequate generation of an outline in $O_1$ (see online version for colours)

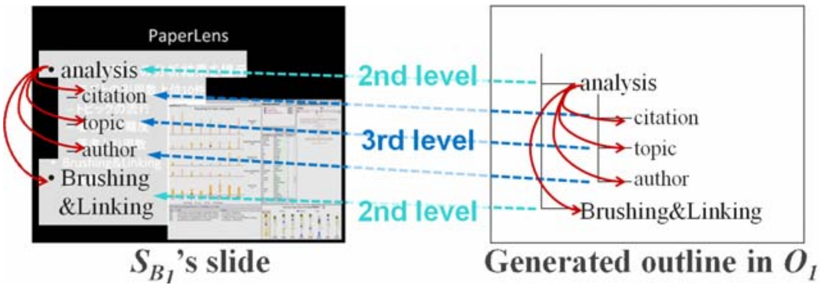
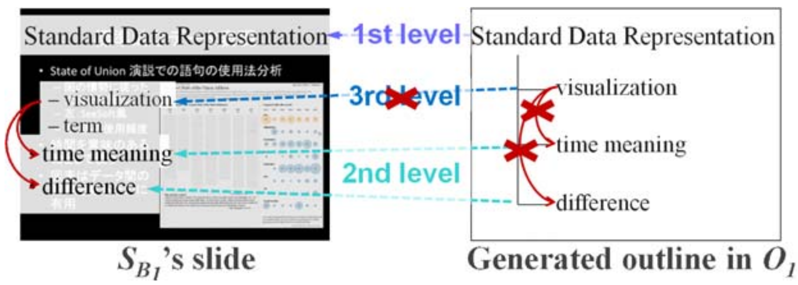



Figure 9 presents an example of inadequate results. An outline in $O_1$ was generated from *B*. At the sentence level, the words 'visualisation' and 'term' appear at the third level, and 'time meaning' and 'difference' appear at the second level in the body of a slide as correct answers in $S_{B_1}$ made by $P_1$. Our method, however, arranged the corresponding words from *B*, 'visualisation', 'time meaning' and 'difference' on the second level in the body of the generated outline in $O_1$; the hierarchical relationships of 'visualisation' and 'time meaning', as well as 'visualisation' and 'difference' were not the same as in $S_{B_1}$'s slide.

**Figure 9** Inadequate generation of an outline in $O_1$ (see online version for colours)



Based on the explanation above, we found that there were only 26.2% (16/61) of the same words in $O_1$ and $O_2$ (see Figures 6 and 7). Although $O_1$ and $O_2$ were generated from the same chapter (*B*), they contained their respective typical words to express the content from *B*. In addition, the same words were characterised by different expression styles in $O_1$ and $O_2$. For instance, 'visualisation' was the main topic of *B*, both in $O_1$ and $O_2$; however, 'visualisation' was a topic in the title of two outlines in $O_1$ and almost half of all outlines in $O_2$. Furthermore, 'cloud' was described at the first half of generated outlines in $O_1$, but it was not described at the first half of generated outlines in $O_2$. Therefore, we confirmed that our method can provide different outlines from the same chapter according to different expression styles and as determined by strategies of presenters/lecturers.

### *5.4 Discussion*

In the evaluation described in the previous subsection, we confirmed that our prototype tool generates outlines with a presentation slide structure that is as expressive as existing presentation slides made by the creator of the first set of slides, as shown in Figures 6 and 7. While the conventional methods generate slides by summarising content in textbook chapters with limited formats, such as the text structures of textbook chapters, our method can generate slides with more variety in layout of referred slides because such freedom of expression of existing slides are specified by users. Specifically, our prototype tool generated different slide outlines from the same resource (e.g. textbook chapters) according to different expression styles based on difference in document structure (i.e. text structure, slide structure) for effectively organising content in the outlines.

Although we confirmed that our method generates outlines with expression styles of the referred slides based on the slide structure, we encountered three main problems. The first problem is that the expression styles, which are based on slide structure, are not regarded as visual effects in slides. In the current age of savvy technology, presenters often focus on visual effects that are easily understandable and more attractive than slides with simple text. We did not initially build the use of font or visual information into our methodology, but it would not be difficult to improve our method by considering such data. Future modifications to this method could include enhancements with visual elements, such as figures, as well as colour distribution and animation occurrence in slides. We can acquire the relevant information to produce such enhancements by analysing XML files from the various presentation formats.

The second problem that we encountered is that the hierarchical relationships between words in the body of text in slides do not yield sufficient semantic representation. Therefore, we need to consider semantic relationships (e.g. *compared-with*, *oppose*, etc.) between the words that can be referred by the Rhetorical Structure Theory (Mann and Thompson, 1988); additionally, we must determine how to utilise these relationships to generate outlines effectively. The third noteworthy problem is that our outline-generation algorithm does not organise content in slides based on the expression styles of phrases (instead of words). We recognise that instructors often extract phrases from textbook chapters to produce a presentation slideshow for lectures. Determining the expression styles of phrases may offer better support for generating outlines.

## 6 Concluding remarks

In this paper, we have proposed a method for generating outlines that provides support for slide-making based on expression styles of words in referred slides specified by users. We have described our methodology in detail, including how expression styles are extracted with the use of slide structure. Additionally, we have explained how we can analyse differences between the words within text structures of textbook chapters and slide structures of their slides by extracting tendency of word appearance from each. Our idea was to organise slide layouts from target chapters in textbooks as the expression styles of referred slides (specified by presenters). To generate outlines for slides from a target chapter, we extracted the words in the target chapter that corresponded to the words in a referred chapter; then, we used the same expression styles of the words in the referred slides to arrange the corresponding words in slide outlines. Through our evaluation, we confirmed that some of the outlines were successfully generated by our semi-automated prototype tool that makes slides by referring to existing slides. We gained new insight into the domain of outline-generation that should contribute to the design of new support tools for presenters. For future research, we need to extend the definition of slide outlines; in other words, we plan to improve our algorithm of outline generation for presentation slides from textbook chapters to consider the changes in context between word use in chapters and word use in slides. Further, we need to develop a system for specifying what information in the chapters needs to be described in the corresponding slides. Finally, we will need to evaluate the effectiveness of this developing methodology.

In summary, we must consider the expression styles of phrases and the semantic relationships among phrases. In addition, we wish to confirm (and quantify) if less effort is required by users using our prototype tool when they are creating presentation slides. Additionally, we would like to explore further strategies for generating different slide outlines from the same resource according to different expression styles. Therefore, we plan to conduct an experiment with participants who actually use our generated outlines for making slides to verify whether they find our method useful.

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