An Exploratory Search Method for Presentation Contents based on User Browsing Behavior

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Abstract MOOC is a crucial platform for improving education; students are able to browse various educational presentation contents through the Web. Any single presentation content can only cover a small fraction of knowledge in a specific domain, and thus offers a limited depth of information. Students then have to go through various presentation contents, but this would be time-consuming and difficult to explore. Therefore, we propose a novel exploratory search tool for presentation contents based on a meaningfully structured presentation by using slides, called an interactive poster. The interactive poster places textual and graphic elements of slides in a structural layout with a zooming user interface by semantically analyzing the slide structure. Through this, our exploratory search can support students interactively browsing an interactive poster with their operations, for retrieving and navigating information from other presentation contents maps students' specific needs by considering the students' browsing behavior on the structure of the interactive poster. In this paper, we discuss two types of exploratory search, (1) topic focused searching based on well-matched browsing behavior that enables users obtain details of specific topics; and (2) exploratory browsing based on distributed browsing behavior that enables the users find various relevant information on topics of interest.

Key words exploratory search, browsing behavior, presentation contents, interactive poster

1. Introduction

Slide-based presentation tools, such as Microsoft PowerPoint or Apple Keynote is now one of the most frequently used tools for educational purposes currently. A huge amount of slide-based educational materials for MOOC, are freely shared on Web sites such as SlideShare(注1) and Coursera(注2). Thus, not only students who missed a lecture or presentation, but also anyone interested in a topic can study the presentation on their own. Therefore, techniques are in demand that will efficiently find appropriate information worth learning from the vast numbers of presentations available. Although many techniques for searching and recommending presentation slides have been proposed, some problems remain from the viewpoint of exploratory search. One problem is current slideshow mode of presentations does not allow users operate freely on the presentations. Recently, Prezi(注3) provides an infinite canvas with a zooming user interface (ZUI) as an alternative to the traditional slides. This interface permits the canvas format to support the creation of expressive layouts, which enables users interactively operate the presentations. Another problem is any single educational presentation material only cover a small fraction of knowledge in a specific domain by a given query, and thus offers a limited depth of information. The users then have to go through various presentation materials for their learning, but this will be time-consuming and difficult to find relevant information from multiple presentation contents. Therefore, users will be required to browse them in structural layouts with ZUIs, and easily explore information meets the users' specific needs by considering user browsing behavior.

As depicted in Figure 1, we present an exploratory search tool that generates a meaningfully structured presentation by using the presentation slides, which is called an interactive poster. With our exploratory search, (1) users can interactively browse an interactive poster is generated by using presentation slides, therefore, (2) the interactive poster can explore information from other presentations by considering user browsing behavior; and (3) represent and navigate

(注1): http://www.slideshare.net/
(注2): https://www.coursera.org/
(注3): http://prezi.com/

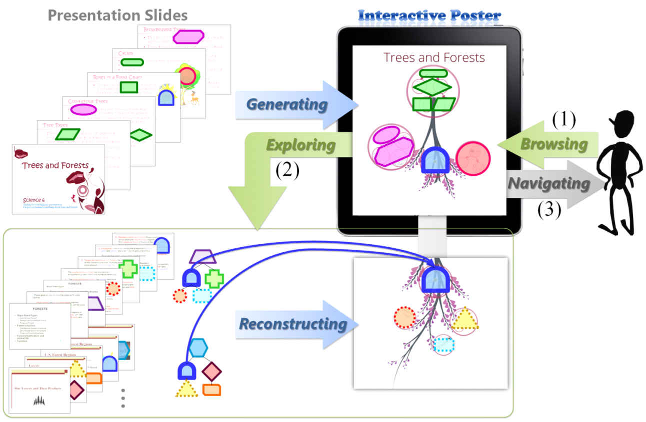

Figure 1 Conceptual diagram of an exploratory search tool

information meets the users' specific needs. To achieve our goal, an interactive poster can be implemented by 1) semantic structure analysis of elements (i.e., textual and graphic elements) in slides and semantic relationships between them; and 2) structural layouts with zooming and panning transitions for organizing elements based on a basic idea of Prezi. In semantic structure analysis, we first extract elements by examining the presentation context of the particular elements in the slides. The semantic relationships between these elements are determined using implicit hyperlinks in slides, based on a slide structure. Specifically, we derive the slide structure by focusing on the itemized sentences in the slide text. There are various types of structural layouts for constructing an interactive poster, such as hierarchical structure, stacked Venn, and pyramid structure. In order to provide an overview of the content, we utilize a hierarchical structure, combined with a stacked Venn for an interactive poster. Finally, our interactive poster is generated based on semantic relationships, using a ZUI, which can enable users to explore the presentations easily and efficiently.

The next section reviews related work. Section 3 describes our semantic structure analysis model. Section 4 explains the generation of interactive poster with zooming and panning transitions. Section 5 presents two types of our exploratory search for presentations. Finally, Section 6 concludes this paper with suggestions for future works.

2. Related Work

A variety of applications address the weaknesses of the current slideware tools in the presentation and authoring domains. Our approach in an interactive poster builds on the strength of exploratory search. Automated generative tools also address the issue of presentation layout and structure. They instead create media artifacts intended to be viewed non-interactively [3], [8]. In the presentation delivery realm, recent research has addressed the question of how to convey complex relationships among slides. MultiPresenter, integrates support for a second slide display so that multiple slides may be related in space as well as time [6]. Although the interactive poster does not adopt the dual-audience-display paradigm, it addresses the need to navigate through elements dynamically during the presentation. NextSlidePlease [10] creates and delivers slideware presentations. The interactive poster is similar to this work, as we utilize a structural layout with the ZUI, to allow users interactively browsing and automatically navigating for users.

Exploratory is constantly being changed and shaped by a range of related research. On the web "the need behind the query" might be Informational, Navigational, and Transactional [2]. Bates [1] suggests that browsing is a cognitive and behavioral expression of exploratory behavior and she claims that it has four elements: (1) glimpse a scene; (2) target an element of a scene visually and/or physically; (3) examine items of interest; and (4) physically or conceptually acquire or abandon examined items. Therefore, our interactive poster according to this, offer an overview (glimpses), the ability to operate the content through various presentations (exploratory browsing). Choo and colleagues [4] developed a model of online information seeking that combines both browsing and searching. It suggests that much of Ellis's model [5] is already implemented by components currently available in Web browsers. We then applied this model for searching presentation contents by considering user browsing behavior on the interactive poster.

3. Analysis of Presentation Contents

In this section, we describe a semantic structure analysis model for extracting elements of presentation slides and determining the semantic relationships between them.

3.1 Element Extraction

There are two important elements, i.e., textual elements and graphic elements, from presentation slides based on itemized sentences of bullet points in the slide text. We define the slide title is the 1st level, the first item of text within the slide body is the 2nd level, and the depth of the sub-items increases with indentation level (3rd level, 4th level, etc.).

3.1.1 Textual Elements

We define textual elements as topics that focus on the nouns in slides. Based on the presentation context, a topic can be described as a learning point with multiple nouns that frequently appears at the higher levels (i.e., the slide title) in neighboring slides. Initially, we extract noun phrases using a language analysis toolkit MSR Splat[注4] based on the XML files of slides. The topic that appears in the title of a slide

(注4): http://research.microsoft.com/en-us/projects/msrsplat/

and the body of other slides can be considered to indicate its context in a presentation. Then, we extract topics by locating the same noun phrases in different slides, at varied levels. If a noun phrase k appears at different levels in slides s_i and s_j, then k is a candidate for being one of the topics T in the presentation. The steps to determine T using k is explained here, which is presented, in s_i and s_j.

$$T = \{(k, s_i, s_j) | l_{max}(k, s_i) \neq l_{max}(k, s_j)\} \quad (1)$$

where, T is a bag of noun phrases that can be considered as candidates for topics. $l_{max}(k, s_i)$ is a function that returns the highest level of k in the slide s_i. For instance, when the highest level is the title, i.e., the 1st level of s_i, then $l_{max}(k, s_i)$ returns 1; and when the highest level is the 3rd level of s_j, then $l_{max}(k, s_j)$ returns 3. When k appears at different levels, k is determined as a candidate for topics provided $l_{max}(k, s_i)$ is not equal to $l_{max}(k, s_j)$. Then, the weight of k in T is defined using the levels of k, and the distance between slides s_i and s_j, as follows:

$$I(k) = \frac{1}{l_{max}(k, s_i)} + \sum_{k, s_i, s_j \in T} \frac{1}{l_{max}(k, s_j)} \cdot \frac{1}{dist(s_i, s_j)} \quad (2)$$

where $l_{max}(k, s_i)$ indicates the weight of k in s_i, it returns the highest level of k in slide s_i by Eq. (1). $dist(s_i, s_j)$ corresponds to the strength of the association between s_i and s_j, and it denotes the distance between s_i and s_j. Thus, if k appears at a high level in s_i and s_j, and the distance between s_i and s_j is short, the weight $I(k)$ of k is high.

3.1.2 Graphic Elements

When compared to pure textual elements, figures are more attractive, appealing and informative from a psychological standpoint. Based on the study of search results presentation [7], it can be noted that summaries with figures assist in quicker understanding of the results, thereby helping in arriving at relevant judgments faster. Therefore, we define graphic elements as figures corresponding to the topic candidates in slides, given that the noun phrases in the surrounding text of the figures are similar to the topic candidates. We considered that the figures used to describe the content in slides, and a slide title can be a subject of the content. When the similarity exceeds a predefined threshold by calculating the Simpson similarity coefficient, the figures are recognized as the corresponding images of the topic candidates.

3.2 Determination of Semantic Relationships

Semantic relationships between elements are determined from a document tree of a presentation to enable users obtain relevant information between the key elements. Preliminary ideas are given in an algebraic query model [9] as well.

3.2.1 Basic Definitions and Algebra

A presentation content shown in Figure 2 is represented

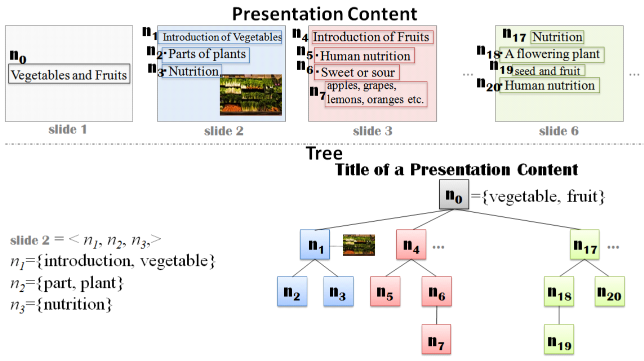

Figure 2 Tree representation of a sample presentation content

as a rooted ordered tree $D = (N, E)$ with a set of nodes N and a set of edges $E \subseteq N \times N$. There exists a distinguished root node from which the rest of the nodes can be reached by traversing the edges in E. Each node n, except the root, has a unique parent node, it of the document tree is associated with a logical component, such as $< title >$ or $< sections >$, based on an XML file in the given presentation. There is a function $words(n)$ returns the representative noun phrases of the corresponding component in n. A partial tree of D with a given noun phrase as its root is defined as a fragment f. It can be denoted as $f \subseteq D$. A slide is a fragment by the slide title. In Figure 2, $< n_1, n_2, n_3 >$ is the set of nodes in slide 2 and a fragment of the sample document tree.

To formally define the semantic relationships between the noun phrases from the extracted elements, we first define operations on fragments, and sets of fragments using a pairwise fragment join [9]. Let F_x and F_y be two sets of fragments in a document tree D of a given presentation, then, the pairwise fragment join of F_x and F_y, denoted as $F_x \bowtie F_y$, is defined to extract a set of fragments. This set is yielded by computing the fragment join of every combination of an element in F_x and an element in F_y, in pairs, as follows:

$$F_x \bowtie F_y = \{f_x \bowtie f_y \mid f_x \in F_x, f_y \in F_y\} \quad (3)$$

Figure 3 illustrates an example of operation for pairwise fragment join. It refers the sample document tree in Figure 2. For the given two noun phrases $x = nutrition$ and $y = fruit$, where $F_x = \{< n_3 >, < n_5 >, < n_{20} >\}$, $F_y = \{< n_4, n_5, n_6, n_7 >, < n_{19} >\}$, $F_x \bowtie F_y$ produces a set of fragments $\{< n_3 > \bowtie < n_4, n_5, n_6, n_7 >, < n_5 > \bowtie < n_4, n_5, n_6, n_7 >, < n_{20} > \bowtie < n_4, n_5, n_6, n_7 >, < n_3 > \bowtie < n_{19} >, < n_5 > \bowtie < n_{19} >, < n_{20} > \bowtie < n_{19} >\}$.

3.2.2 Semantic Filters

We determine semantic relationships between the given topics, x and y, from the extracted elements using the set of fragments produced by taking pairwise fragment join as semantic filters. For this, we define four types of semantic filters by considering the horizontal and vertical relevance,

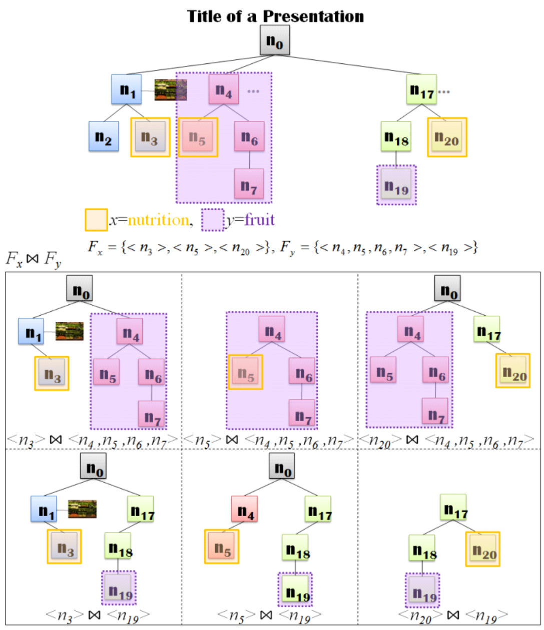

Figure 3　An example of pairwise fragment join

as well as the structural semantics from the document tree.

Horizontal distance　When the horizontal distance between the nodes in slides containing x and y exceeds a certain threshold, x is irrelevant to y. Supposing, $hdist(t_i, t_j)$ denotes the distance between the nodes of the slide titles t_i and t_j in slides containing x and y, we set the threshold value α at $|N|/2$, i.e., half the total number of nodes N in the document tree, for normalizing various presentations. If $hdist(t_i, t_j)$ does not exceed α, then the distance between two slides containing x and y is near (i.e., relevant); contrarily, if $hdist(t_i, t_j)$ exceeds α, the distance between two slides containing x and y is far (i.e., irrelevant).

Vertical distance　When the distance between the slides containing x and y is far, and x and y are at the low levels in slides, they can be less relevant in the document tree. When vertical distance between the nodes in slides containing x and y exceeds a certain threshold, and x and y are at the low level in the slides, x is irrelevant to y. Supposing, $vdist(r, q)$ denotes the distance between the root node r and the node containing each given noun phrase q (e.g., x or y), we set the threshold value β at $ave(depth)$, which is an average of the depth of levels in the document tree, for normalizing various presentations. If $vdist(r, q)$ does not exceed β, then the level of the node containing x or y is high (i.e., relevant); contrarily, if $vdist(r, q)$ exceeds β, the level of the node containing x or y is low (i.e., irrelevant).

Hierarchy　For judging the semantics of x and y, we compare the levels of x and y in the fragments based on the theory of hierarchical semantics. When $l(x) < l(y)$, the level of x is higher than the level of y; x is a superordinate concept of y (y is a subordinate concept of x). Contrarily, $l(x) > l(y)$ denotes that the level of x is lower than the level of y; x is a subordinate concept of y (y is a superordinate concept of x). When $l(x) = l(y)$, the level of x is same as the level of y; they have coordinate concept.

Table 1　Semantic relationships with semantic filters

Types	Horizontal	Vertical	Hierarchy	Inclusion
x *shows* y	$< \alpha$	*either*	$l(x) < l(y)$	*either*
x *shows* y	$\geqq \alpha$	$< \beta$	$l(x) < l(y)$	*either*
x *describes* y	$< \alpha$	*either*	$l(x) > l(y)$	*either*
x *describes* y	$\geqq \alpha$	$< \beta$	$l(x) > l(y)$	*either*
x *likewise* y	$< \alpha$	*either*	$l(x) = l(y)$	*either*
x *likewise* y	$\geqq \alpha$	$< \beta$	$l(x) = l(y)$	*either*
x *has-a* y	$< \alpha$	*either*	*either*	$f_x \supseteqq f_y$
x *has-a* y	$\geqq \alpha$	$< \beta$	*either*	$f_x \supseteqq f_y$
x *part-of* y	$< \alpha$	*either*	*either*	$f_x \subseteqq f_y$
x *part-of* y	$\geqq \alpha$	$< \beta$	*either*	$f_x \subseteqq f_y$

Inclusion　The inclusion relationships exit between the fragments of x and y. When $f_x \subseteqq f_y$, the fragment of x is included in the fragment of y, i.e., f_x is a partial tree of f_y. Contrarily, when $f_x \supseteqq f_y$, it denotes that the fragment of x includes the fragment of y, i.e., f_y is a partial tree of f_x.

3. 2. 3　Semantic Relationship Types

We determine five types of semantic relationships between the given noun phrases, x and y, by combining the semantic filters of Table 1. For measuring the relevance between x and y, we focus on the **horizontal distance** and the **vertical distance**. Here, when the **horizontal distance** between them is long, the **vertical distance** should be short. We determine hierarchical relationships, x *shows* y, x *describes* y, and x *likewise* y, by focusing on **hierarchy**. In x *shows* y, $l(x) < l(y)$ means x is a superordinate concept of y (y is a subordinate concept of x). In x *describes* y, $l(x) > l(y)$ means x is a subordinate concept of y (y is a superordinate concept of x). Then, *show* and *describe* are functionally interchangeable, when x *describes* y is from the viewpoint of y *shows* x. In x *likewise* y, $l(x) = l(y)$ means x and y have coordinate concept with each other. We determine inclusion relationships, which are x *has-a* y and x *part-of* y, by focusing on **inclusion**. In x *has-a* y, $f_x \supseteqq f_y$ means that the concept of x includes the concept of y. In x *part-of* y, $f_x \subseteqq f_y$ means that the concept of x is included in the concept of y. Then, *has-a* and *part-of* are functionally interchangeable, when x *part-of* y is from the viewpoint of y *has-a* x. When x and y fail to match these determinations of semantic relationships, x and y are independent. Therefore, a numbers of semantic relationships between x and y are formed from a set of fragments produced by taking the pairwise fragment join; a semantic relationship is determined by majority.

In this work, we conduct multiple presentations based on the semantic structure analysis in a given domain, the semantic relationships follow a transitivity law, e.g., iff x *shows* y in presentation A, y *shows* z in presentation B, then it is assumed that x *shows* z.

4. Interactive Poster Generation

We generate an interactive poster possessing two features: (1) providing an overview of elements from the slides, retaining this feature of traditional posters; and (2) utilizing a ZUI, promoting user browsing behavior and reflecting the semantics of the elements on the interactive posters.

4.1 Determination of Element Layouts

For providing an overview of elements from slides, we attempt to utilize a hierarchical structure combined with a stacked Venn, based on the semantic relationships between the elements. When hierarchical relationships between two elements, i.e., either *show*, *describe*, or *likewise* exists between the elements, they reveal a hierarchy between those elements, as applied to a hierarchical structure. *Show* or *describe* maps a parent-child relationship in the hierarchical structure; if x *shows* y (y *describes* x), then we mark x in a parent area and y in a child area, suggesting that the layer of x is higher than the layer of y. Additionally, *likewise* maps a sibling relationship in the hierarchical structure; if x *likewise* y, then we locate x and y in the same layer. Inclusion relationships between two elements, i.e., *has-a* and *part-of*, reveals a logical relationship of inclusion and exclusion applied, as to a stacked Venn. If x *has-a* y (y *part-of* x), we conceive an area of y that is included in an area of x, and that the area of x is larger than the area of y.

4.2 Determination of Element Transitions

To utilize a ZUI, (1) users can browse the interactive posters with their operations, such as zoom-in, zoom-out, and pan; (2) users can browse the interactive posters without their operations by automatically navigations with transitions between elements. The transitions discussed here explain the kinds of visual effects that are applied to the semantic relationship types, to reflect the meaning of the elements from the slides. We animate the zooming and panning transitions for navigating through elements; this can help users to visually understand the overview and details of the contents within a presentation.

4.2.1 Transitions for *show* (*describe*)

When *show* (*describe*) between two elements. Then, firstly the view must be zoomed-out from the focused element to an area of both, following which; it must be zoomed-in to the target element. Therefore, the transitions include passing through the area of both, which helps users to easily grasp the super-sub relation existing between them.

4.2.2 Transitions for *likewise*

When *likewise* between two elements, the transitions between the two elements include zooming-out from the focused element to an area enclosing both the elements and their parent element, and then zooming-in to the target element. Therefore, the transitions provide their parent element that can help users easily to know they are subservient to the same concept.

4.2.3 Transitions for *part-of* (*has-a*)

When *has-a* (*part-of*) between two elements, the transition between the two elements pans from the focused element to the target element. Therefore, this simple and direct transition between the two elements helps users to easily understand that they are dependent on each other, and that there exists an inclusion relationship between them.

In addition to the above, the transitions between two independent elements include zooming-out from the focused element to all elements, and then zooming-in to the target element. Therefore, these transitions help the user to easily know that they are irrelevant.

As depicted in Figure 4, we generated interactive posters using actual Lecture ♯1 for Database at Stanford University[注5] and Portland State University[注6]. We found that a lecture emphasized the content of 'DBMS' at Stanford University, and a lecture emphasized the content of 'Relational Database' at Portland State University. Then, we confirmed that different universities take different contents in the same lecture by grasping overviews of them with our interactive posters. Then, they can supplement each other, for instance, a user wants to obtain details of 'Relational Database,' when the user browses the lecture at Stanford University.

5. Exploratory Search based on User Browsing Behavior

Based on the the interactive poster generation, we build an exploratory search tool that aids users to interactively search multiple presentations in search results by a given search query. There are two types of exploratory search: (1) focused searching and (2) exploratory browsing. Therefore, we measure dependence of the structure of the interactive poster based on user browsing behavior, as follows:

$$D(H) = \frac{1}{|H|-1} \sum_{n=1}^{|H|-1} \frac{1}{dist(e_n, e_{n+1})},\ e_n \in H \qquad (4)$$

Here, H is a browsing history based on user browsing behavior. e_n and e_m are browsed elements in H. In this work, we define the browsed elements, focusing on zoom-in operations of elements by the users, that the elements can be considered as the users are interested in. Then, we calculate

(注5) : http://infolab.stanford.edu/~widom/cs145/intro-db.ppt
(注6) : http://web.cecs.pdx.edu/~howe/cs410/lectures/Relational_Intro_1.ppt

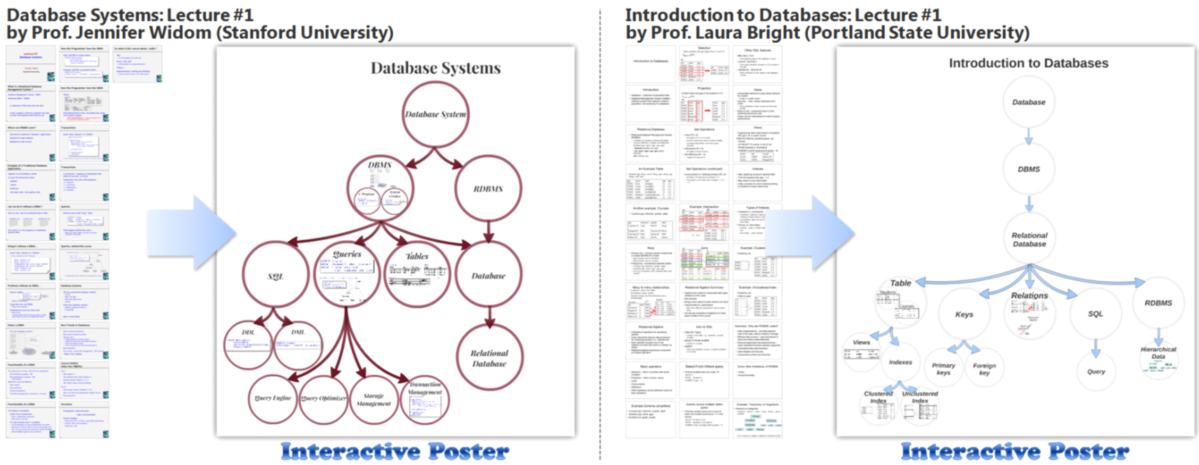

Figure 4 Examples of generated interactive posters based on our proposed method

a degree of $D(H)$ by using average of relevance between the browsed elements. Function $|H|$ returns the number of the browsed elements. Then, $|H|-1$ denotes the number of edges between the browsed elements. $dist(e_n, e_{n+1})$ is a shortest distance between e_n and e_{n+1} in an order. The shortest distance is calculated by the number of edges between the browsed elements on the structure of the interactive poster, then, $dist(e_n, e_{n+1}) \geqq 1$. When $dist(e_n, e_{n+1})$ returns 1, the relevance between e_n and e_{n+1} is closest. In this case, we set the threshold value γ at $|H|/|E_p|$, $|E_p|$ denotes the number of nodes in a partial tree included all browsed elements of the structure of the interactive poster. If $D(H) \geqq \gamma$, the browsing behavior can be considered well-matched on the structure of the interactive poster; contrarily, if $D(H) < \gamma$, the browsing behavior can be considered distributed on the structure of the interactive poster.

Algorithm 1 Explore $FS = (E_d, R, P)$

Require: x is an element in a given presentation p, last browsed by a user with a zoom-in operation.
Ensure: $R = \{(e, e', r)|e, e' \in E, e, e' \in p'\}$
  $R \Leftarrow \phi$
  for all presentation p' in a given domain **do**
    if r is *show* relationship **then**
      $e \Leftarrow x$
      $R \Leftarrow (x, e', r)$
      $P \Leftarrow p'$
    end if
  end for

5.1 Focused Searching based on Well-matched Browsing Behavior

When a user browses along the structure of the interactive poster focused on a topic and its subtopics with zoom-in operations, we consider the user wants to get details of the focused topics. In this case, we assume that it is topic focused searching based on well-matched browsing behavior on the structure of the interactive poster, which helps the user get details of the last browsed topic from other presentations. Algorithm 1 describes a procedure for exploring elements in a sub-structural layout $FS = (E_d, R, P)$ from multiple presentations based on topic focused searching. E_d is a set of elements related to x by users' operations as an input. r is a type of semantic relationships R defined in Table 1. P is a set of presentations in search results by a given query. This procedure represents e' related to x according to (x, e', r), in which r is *show* for finding details of x.

Algorithm 2 Explore $EB = (E_w, R, P)$

Require: x, y are elements in a given presentation p, browsed by a user with a zoom-in operation.
Ensure: $R = \{(e, e', r)|e, e' \in E, e, e' \in p'\}$
  $R \Leftarrow \phi$
  for x, y such that $(x, y, r) \in R$ in p **do**
    for all presentations p' in a given domain **do**
      if r is *likewise* relationship **then**
        $e \Leftarrow x$
        $e \Leftarrow y$
        $r \Leftarrow describe$
        $R \Leftarrow (x, e', r) = (y, e', r)$
        $P \Leftarrow p'$
        if r is *descibe* relationship **then**
          $e' \Leftarrow z$
          $R \Leftarrow (e, z, r)$
          $P \Leftarrow p'$
        end if
      end if
    end for
  end for

Figure 5 illustrates an example of focused searching, a user firstly zooms-in to the area of 'Forests and Humans,' after that zooms-out from it and zooms-in to the area of 'Forests,' and zooms-in 'Trees' on the interactive poster. We considered that the user wants to obtain details of 'Trees' along

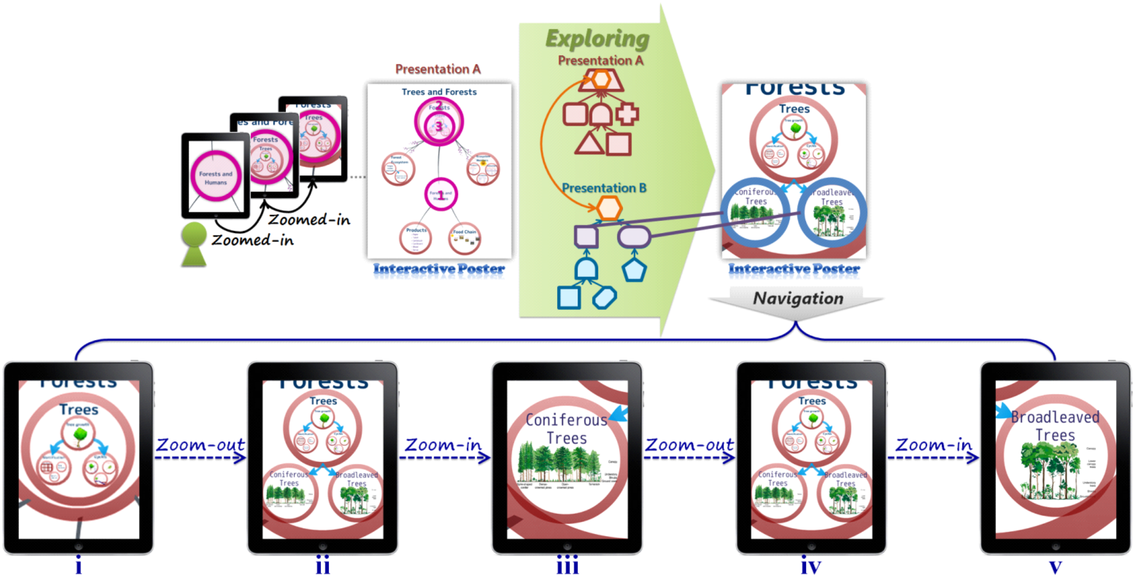

Figure 5　An example of focused searching based on well-matched browsing behavior

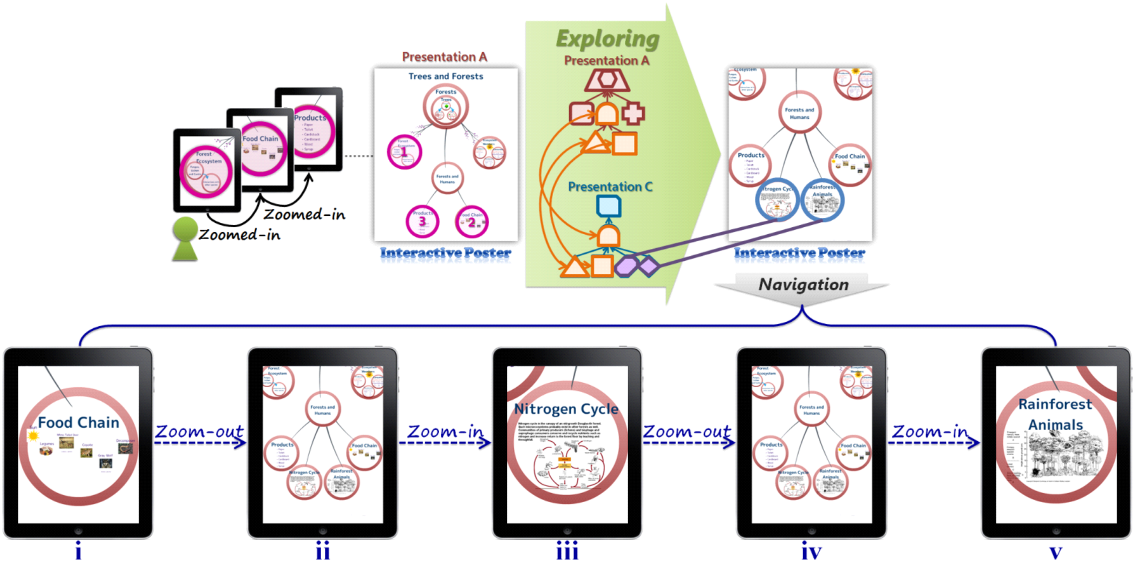

Figure 6　An example of exploratory browsing based on distributed browsing behavior

the content related to ‘Forests.’ Therefore, the interactive poster represents a whole area of ‘Trees’ with its details (i.e., ‘Coniferous Trees’ and ‘Broadleaved Trees’). Although Presentation A[注7] does not exist details of ‘Trees,’ in this work, we can extract ‘Coniferous Trees’ and ‘Broadleaved Trees’, which *describe* ‘Trees’ from Presentation B[注8], and represent a whole and represent a whole area of ‘Trees’ with them. In addition, the interactive poster can automatically navigate the whole area of ‘Trees’ to the areas of its details (i.e., ‘Coniferous Trees’ and ‘Broadleaved Trees’). As shown in Figure 5, the interactive poster firstly zooms-out from the area of ‘Trees’ is shown in **i** to the whole area of ‘Trees’ is shown in **ii** that gives the user an overview of ‘Trees,’ after that the interactive poster zooms-in to the area of ‘Coniferous Trees’ is shown in **iii**. This enables the user to obtain ‘Coniferous Trees’ is a detail of ‘Trees.’ Next, the interactive poster zooms-out from the area of ‘Coniferous Trees’ is shown in **iii** to the whole area of ‘Trees’ again is shown in **iv**, after that the interactive poster zooms-in to the area of ‘Broadleaved Trees’ is shown in **v**. This enables the user to obtain ‘Broadleaved Trees’ also is a detail of ‘Trees.’

5.2 Exploratory Browsing based on Distributed Browsing Behavior

When a user browses topics in apart on the interactive poster, we consider the user wants to get a lot of relevant information related to the browsed topics. In this case, we assume that it is exploratory browsing based on distributed

（注7）: http://teacherweb.com/AB/GilbertPatersonMiddleSchool/MsDavid/Tree-Types-2b-Posting-version.ppt
（注8）: http://www.marinepolicy.net/cparsons/Ecology/12-Forests.PPT

browsing behavior on the structure of the interactive poster, which helps the user find a lot of relevant information on topics of interest from other presentations. Algorithm 2 describes a procedure for exploring elements in a sub-structural layout $EB = (E_w, R, P)$ from multiple presentations based on exploratory browsing. E_w is a set of elements related to x and y by users' operations as an input. This procedure represents e' related to x and y according to (x, y, r), in which r is *likewise* for finding relevant information of x and y.

Figure 6 illustrates an example of exploratory browsing, a user firstly zooms-in to the area of 'Forest Ecosystem,' after that zooms-out it and zooms-in to the area of 'Food Chain,' and zooms-out it and zooms-in to 'Products.' We considered that the user wants to get a lot of information about 'Food Chain' and 'Products' along the content related to 'Forests and Humans.' Due to 'Products' *likewise* 'Food Chain,' and they *describe* 'Forests and Humans,' 'Forests and Humans' has its details (i.e., 'Products' and 'Food Chain') only in presentation A (see Figure 4). In this work, we can extract 'Nitrogen Cycle' and 'Rainforest Animals', which *describe* 'Forests and Humans' from presentation C, and represent a whole of 'Forests and Humans' with its details (i.e., 'Products,' 'Food Chain,' 'Nitrogen Cycle,' and 'Rainforest Animals'). In addition, the interactive poster can automatically navigate the whole area of 'Forests and Humans' to the areas of other details (i.e., 'Nitrogen Cycle' and 'Rainforest Animals'). As shown in Figure 6, the interactive poster firstly zooms-out from the area of 'Food Chain' is shown in **i** to the whole area of 'Forests and Humans' is shown in **ii** that gives the user an overview of 'Forests and Humans' with its other details 'Nitrogen Cycle' and 'Rainforest Animals.' This enables the user to obtain other details 'Nitrogen Cycle' and 'Rainforest Animals' of 'Forests and Humans.' Next, the interactive poster zooms-in to 'Nitrogen Cycle' and 'Rainforest Animals' are shown in **iii** and **v**, respectively. It helps the user to understand details 'Nitrogen Cycle' and 'Rainforest Animals' of 'Forests and Humans.'

6. Conclusions

In this paper, we built an exploratory search tool for presentation contents based on interactive poster generation, which represents elements (i.e., textual and graphic elements) in a meaningfully structured layout with automatic transitions, such as zooms and pans, to promote user interaction. Especially, we introduced a semantic structure analysis model for extracting elements and determining semantic relationships between the elements of slides. In order to generate an interactive poster, we initially placed the elements in a hierarchical structure combined with a stacked Venn. We then attached the zooming and panning transitions between the elements, based on the semantic relationship types. The interactive poster enables users to browse, and explore easily and efficiently through various presentations. Finally, we used our collected 25 academic presentations (392 slides) from DEWS and DEIM in DBSJ Archives, and 25 actual lecture contents (432 slides) about social informatics from lecture archives at universities (i.e., Tsukuba University, Aoyama Gakuin University, etc.) for evaluating exploratory searching method based on interactive poster generation, such as accuracy of topic extraction (69.1%), validity of overviews and navigation of interactive posters.

In the future, we need to discuss experimental results of interactive poster generation in detail. Further, we plan to consider a collaborative exploratory searching tool, which will provide a way to summarize already encountered information. The tool could tailor these summaries to the respective skill levels of collaborators.

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