Goal-based Visual Navigation Support for Educational Resources

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Abstract

Information visualizations can add great advantages in the classrooms by helping students access appropriate educational resources in order to achieve their course objectives. We present a novel adaptive visualization methods that support goal-based navigations for class materials. In our education support system, map-based adaptive annotation, relevance-based visualization, and visual control for search system that mixes different models involved in the goal-based navigation. We are going to use the system in a real class and will conduct a user study in order to validate the effectiveness of the idea.

1 Introduction

While taking courses, students are loaded with various resources and it is an important task to guide them to relevant materials more efficiently. They need to read and use the class materials that are closely related to the goal of each class. It could waste too much time and effort to read class textbooks just randomly or sequentially. We need a smarter method that can advise the students which material could benefit them most efficiently according to their class goals.

Information visualization can add advantages in this context. Is an efficient method that can interactively manipulate large amount of data [Shneiderman, 2001]. It can help the students to select and prioritize relevant resources – textbooks, handouts, reference materials, examples and quizzes, etc. – in order to achieve the class goals. Traditionally, human instructors, classmates, or seniors have taken this role to guide the students. However, new educational resources are rapidly added in today's information environment and it is not easy to timely catch up with this speed. The information overload is prevailing in the classroom too.

Information visualization systems for educational resources are good options in order to automate and assist the instructors with more powerful guidances. Those systems would be able to help the students navigate through the sea of educational resources interactively and visually. Moreover, it would be great if they could recommend relevant items that match the students' current interests or progress during the courses.

In our previous projects, we have tried a map-based (self-organizing map [Kaski et al., 1998]) social annotations in order to incorporate the group (classmates) wisdom for better navigation of students in the visualization [Brusilovsky and Rizzo, 2002b, Brusilovsky and Rizzo, 2002a]. We also used this social annotation information for searching, in order to visualize the items preferred by the group users in the search results [Brusilovsky et al., 2005].

In the ADVISE 2D project [Brusilovsky et al., 2006], we used the well-known Force Directed Placement (FDP) algorithm [Eades, 1984] in order to visualize C-language education examples. With the location of the example placements and annotations drawn on top of example icons, the system could present the examples in the context of relatedness and the progress of the students. The QuizVIBE project [Ahn et al., 2006] exploited the relevance-based visualization algorithm called VIBE (Visual Information Browsing Environment) and presented the C-language quizzes. The core concepts for solving C-language quizzes were defined as reference points and the quizzes were visualized according to their similarities to the quizzes. Moreover, the students could adaptively select quizzes according to their progress in the course of learning.

In this paper, we introduce our novel adaptive visualization methods for goal-based educational resource recommendation. Three visualization methods were integrated into a single educational information access framework: (1) a personalized self-organized map with adaptive visible cues according to different goals covered in classrooms, (2) a relevance-based visualization for representing multiple goals, and (3) a personalized search system that can selectively adjust the importance of the goals in search results.

2 Goal-based Navigation Support for Educational Resources

2.1 Map-based Lecture Topic Visualization

Figure 2 is the screenshot of the self-organizing map (SOM) based educational resource access system called KnowledgeSea. It implements the topic-based navigation with other features. The system organizes open corpus C-language tutorials, scanned pages of five textbooks used in the INFSCI2470 Interactive System Design class, and six textbooks used in the INFSCI2140 Information Storage and Retrieval class at the School of Information Sciences, University of Pittsburgh.

The SOM algorithm implementation in Figure 2 (above) generated 64 clusters according to the inter-similarity values of the textbook sections and arranged them on the map visually, so that related documents are placed together spatially on the map. The eight by eight square cells in the visualization represent the clusters that include inter-related documents within it.

The smaller (below) shows one cell content, listing the document titles linked to fulltexts. Students can select a cell after checking three title keywords, and then access individual documents using the cell view. The blue background colors (on the map or in the cell) represent the access frequency of the group members (e.g. classmates), with darker blue colors meaning higher traffic. The foreground colors of the human icons mean the current user's access information. Students can check which resources are popular

Figure 1: KnowledgeSea with the goal-based navigation support. The green icons represent how relevant the materials (textbook sections) in the corresponding cells are to the class goal.

among their peers.

This social information is relying on the group wisdom of the peers. However, due to the nature of the classroom learning, it is also important to guide the students according to the teaching plans designed by the instructors. The goal-based adaptive navigation can address this requirement. The green topic icons (Figure 3) added beside the human icons represent the relevance of a cell or a document in terms of the lecture topics. Students are first asked to select on of the topics covered in the class (e.g. *Analysis, Prototyping, Evaluation* in Figure 2) and then the topic icons are painted in different shades. Darker green means less relevance and brighter green means higher relevance (Figure 3). Therefore, the students can find out promptly which resources are closely related to the specific class topic, along with the information about the content similarity of the neighboring resources and the peer preferences in a single visual map.

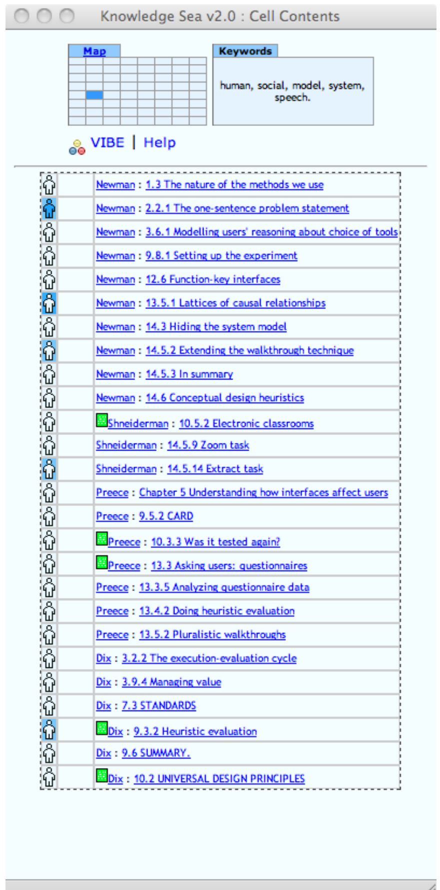

Figure 2: KnowledgeSea with the goal-based navigation support cell view. The green icons beside the resource title represent the goal-relevances.

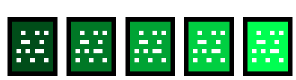

Figure 3: Icons indicating different goal relevance

2.2 Visual Topic Model for Goal Representation

When the topic is selected by the users, the topic model in the form of keywords or phrases are displayed above of the map (e.g. *analysis, evaluation, 'support of design'*, etc.). This visual topic model has an advantage that the students can easily understand how the system works. It can also refresh the students with the core *concepts* of the given topic and can help them to understand how the concepts are connected to the topics/texts.

In order to extract the concepts for each topic, we processed the presentation slides used in the past lectures. Because the slides were organized by the class topics, standard text processing methods were easily applied to extract relevant concepts for each topic. The topic model was compared with each document to calculate the relevance (and to select the icons). The cell relevance was calculated as the sum of the documents included in each of them.

2.3 Relevance-based Visualization for Representing Multiple Goals

In addition to the map-based visualization, we also support the relevance-based visualization and arrange spatially the lecture topics and the related documents. In Figure 4, we implemented the VIBE (Visual Information Browsing Environment) [Olsen et al., 1993] visualization to show the topics as reference points, called POIs (Points of Interest) painted in green circles. It was implemented in JavaScript, so that it could be natively integrated into the map view or the cell view of KnowledgeSea.

The POIs (green circles) represent the 12 topics covered in the INFSCI2470 Interactive System Design course and the white squares are educational resources such as textbook sections. The locations of the documents are decided according to their similarity ratios to the POIs. If they are more similar to specific topics they are placed closer to them. For example, the three squares (lower right) in the figure are located closer to the topics such as "`Analysis, Prototyping, Evaluation`" and "`Extended interface`," so that users can instantly see those documents are about the user interface

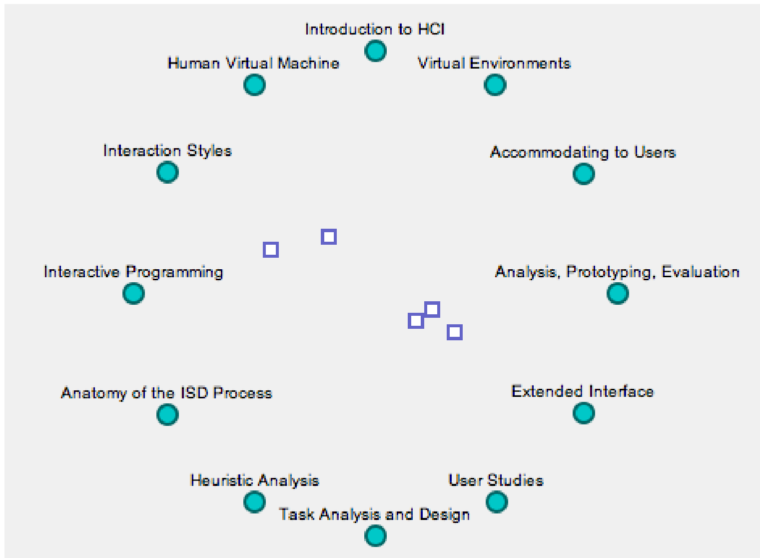

Figure 4: Relevance-based visualization differentiating class resources (squares) according to the lecture topics (circles)

evaluation or the extended user interface issues.

2.4 Goal-based Search Result Personalization

The previous two visualizations mostly support browsing behaviors. The students are provided with a map showing the overview about the materials stored in the database. Then they can select specific topics or goals for further investigation. However, searching is as popular information access method as browsing and it is not an exception among students.

KnowledgeSea supports personalized search and its advantage was reported in [Brusilovsky et al., 2005]. We extended this feature in order to incorporate the goal-based navigation among the personalized search results. Figure 5 and 6 shows an example. It has a traditional ranked list (left) with the social information annotated (human and hand icons). Along with the list, there appear two additional boxes (right) that are labeled as “Task Model” and “Lecture Model.”

In this system, three core elements decide the rank of the resources: (1)

user query, (2) task model, and (3) lecture model. Along with the traditional query, users can define their *goal* in the form of the "task model" and the "lecture model." The task model is a free-formatted text entered by the students and the lecture model is the pre-defined goals by the instructor. By combining these three elements, the search system can provide more optimal personalized search results conforming the goals of the classes.

However, the mixture of those different variables within the single search system raised a fundamental question. *How to balance each element?* In order to solve this problem, we borrowed the idea of *exploratory searching* [Marchionini, 2006], which emphasizes users' active participation to the system using interactive user interfaces.

We provide a triple-slider (Figure 6), with which users can adjust the weights of the three (`''Query'', ''Task'', ''Lecture''`) variables for the search tasks. They can drag the red dot labeled as "`Weight`" within the triangle. As they move the dot closer to a specific point, the system gives more weight to that point. For example, the users moved the red dot very close to the "`Lecture`" and a little bit more closer to the "`Task`" in Figure 6. Therefore, the system gives the maximum weight to the lecture model and then slightly more weight to the task model than the user query, for ranking the search result.

The ranked list is updated whenever the user clicks the "`Apply Weights`" button, so that s/he can examine the updated result and adjust the weights interactively. Using this tool, users can achieve search results adapted either to the class goals or their explicit specification of information needs.

3 Conclusions and Future Works

In this paper, we introduced our approach to visualize the class resources adaptively according to the lecture topics. We showed three approaches: (1) SOM adaptation with varying icon shades according to the topic of interest, (2) VIBE visualization that can spatially arrange the multiple topics and the documents, and (3) a triple-slider user interface that supports a personalized

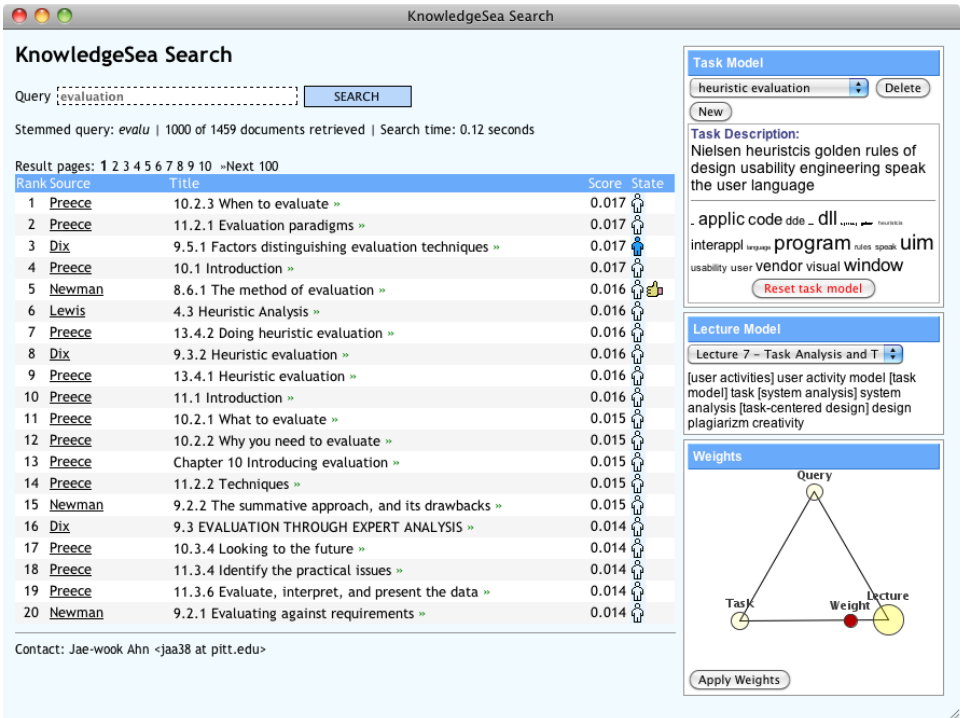

Figure 5: Personalized search for educational resources. “Query,” “task model,” and “lecture model” are contributing altogether to generate the search results.

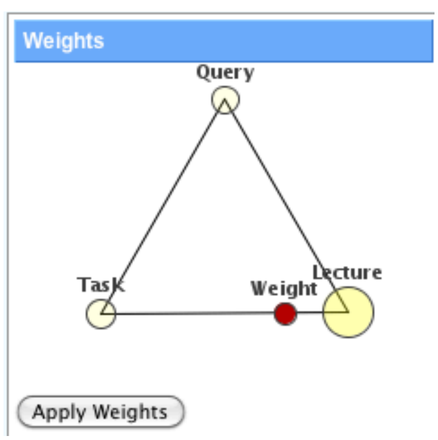

Figure 6: Triple-slider interface for adjusting weights among the three elements.

search system and selectively adjusts the importance of the goals in search results.

We designed and implemented a system called KnowledgeSea with this goal-based adaptive visualization support. It was intended to be used in real classrooms from the initial design stage and we are going to utilize it as a learning support tool in the INFSCI2470 or INFSCI2140 classes at the School of Information Sciences, University of Pittsburgh. We will be able to analyze the usage statistics of the students who take the classes and investigate whether our adaptive visualization ideas could help the students in the real settings.

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