Supporting Creative Learning Experience with Compositions of Image and Text Surrogates

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Abstract: We are exploring new roles for interactive systems in supporting creative processes and aiding in idea formation. combinFormation is an interactive system that uses the information resources of the internet to promote creative thinking. Image and text representations are collected and manipulated in a composition space, which invokes complementary human cognitive subsystems to promote understanding and emergence. An agent works to help the human find relevant information and see combinations of information elements in new ways. combinFormation was introduced into the curriculum of an undergraduate course on The Design Process, in which students' primary responsibility is to develop new inventions. This paper presents our field study and results that demonstrate combinFormation supports students engaged in creative learning experiences. Our goal is to transform the educational paradigm of reproducing existing knowledge toward producing new knowledge.

Introduction

Due to the popularity of digital media devices and the abundance of information on the web, a broad cross-section of society grows more and more exposed to large numbers of digital documents and media elements. This also leads students to move their learning environment into the Internet. The Pew Internet and American Life Project, reporting on 2054 students from 27 colleges and university, says that nearly 73% of college students use the Internet more than the library, while only 9% said they use the brick and mortar library more than the Internet for information searching (Pew Internet & American Life Project, 2002). A surrogate represents an information resource and enables access to that resource (Burke, 1999). In order to support students' experience of finding information and learning in the Internet, we are developing an interactive system, combinFormation, that integrates processes of searching, browsing, collecting, and arranging information through composition of image and text surrogates. combinFormation affords users with the ability to express interest in information surrogates, so the system agent can retrieve relevant information automatically (Interface Ecology Lab 2006).

We begin with by introducing the principles of the combinFormation system, and illustrating its use with a scenario. Next, we provide a background of relevant prior work from fields such as library science, hypermedia, visual design, and cognitive psychology. Next, we describe a field study that was conducted in a large scale undergraduate course, The Design Process, in order to validate how collecting information in the form of compositions of image and text surrogates supports students engaged in creative learning experiences.

combinFormation

We are developing a mixed-initiative system, combinFormation (Interface Ecology Lab 2006), that uses composition to represent information while a person is searching for, browsing, collecting, and arranging image and text clippings from web pages and other documents (see example, figure 1). The clippings act as

visual, semiotic, and navigational surrogates for the documents from which they are extracted; that is, they function as enhanced bookmarks. In combinFormation, the user and agent collaborate to find relevant information resources, form image and text surrogates, and compose the information surrogates in a visual and navigational interactive space. A *mixed-initiative system* is one in which the actions of the user and an agent, working on a joint task, are interleaved (Horvitz, 1999). The initiatives in combinFormation are the user's direct manipulation collecting and composition, and the user's direction of the agent. The agent's generative actions – clipping and collecting information elements to form surrogates, and composing them visually – are conducted iteratively over time, based on a semantic model of the surrogates, their relationships, and the user's interests. One of the user's initiatives is to directly manipulate the composition through interactive design operations, which enable surrogates to be displaced, layered, resized, annotates, and removed. The user can also take initiative to direct the agent by using interactive tools; this includes expressing positive or negative interest in any surrogate. Expressions of interest in surrogates affect the semantic model of the system that direct the agent to retrieve more relevant information to users. The following section presents a hypothetical combinFormation usage scenario.

Usage Scenario

Audrey is a student in The Design Process class. Her assignment is to develop an original invention that is a hybrid of two or more different objects. Audrey's big idea is to develop a wearable location-aware information appliance that uses a high-resolution color display built into the fabric of a shirt sleeve. This device senses the user's current location, and provides contextual location-based information to support tourist activities.

In order to determine whether or not her invention can be developed in the next 3-5 years, Audrey needs to find current technologies which can be adapted for this invention. She previously read an article about a new type of display that is paper thin. Such a display, although not fabric, could provide a building block for the display of the invention. She also remembers a friend telling her about new forms of fabric which are wired to carry electrical charge; such fabrics can have designated areas function as control mechanisms like buttons.

To research the practicality and originality of her idea, Audrey uses combinFormation as a research tool. Audrey seeds combinFormation with searches based on the possible technologies she determined: "paper thin display", "electronic fabrics", and "location aware devices." combinFormation begins downloading and displaying images and text from the search results (See figure 1.). As images and text appear, Audrey uses the navigate tool to open referenced pages and examine these pages for relevant information. One such is an image of a flexible display being bent by a hand. Upon examining this referenced page, she finds the article she had previously read about a paper thin display. She re-reads the article noting important information.

Returning to the composition, Audrey uses the navigate tool on a text element this time labeled, "applications which allow users to interact with their environment". The text element takes her to the website of the tinmunth augmented reality project. Images show people wearing equipment such as goggles which render augmented reality visuals based on a person's GPS location and viewing direction. Another site shows portable eyewear displays that look like eye-glasses. Audrey notes that her invention can use the glasses (since goggles draw undesired attention to a tourist). Looking through the glasses could highlight tourist attractions in view (i.e. historic buildings, statues, art museums) and provide direction information to those out of sight.

Audrey notices elements appearing about touch-sensitive cloth. Another inventive spark occurs and Audrey realizes her fabric display could also be touch-sensitive enabling the user to manipulate the display easily. She uses the navigate tool on an element about the touch-sensitive fabric, bringing up the website for SOFTswitch, a manufacturer of electronic fabrics. She explores the page noting possible devices that could be used for her hybrid invention.

Figure 1: Composition that corresponds to Audrey's research on a wearable location-aware information appliance. Each surrogate is a visual element that can be manipulated, and also enables navigation to source documents. Details on demand are shown for a surrogate about heads-up displays.

Audrey begins moving interesting elements around creating relationships between elements. She juxtaposes elements about the paper-thin display with elements about location-aware devices and electronic fabrics. Audrey arranges the elements by aesthetic design and also in an organizational manner. She is creating this composition not just for herself, but as a deliverable for her assignment so that her professor and classmates can better understand her invention.

Audrey completes the composition and saves it. She brings it to class. Her composition functions as a visual aid in explaining her invention, its practicality, and its originality. Later, her classmates gather information beyond what she presents in class, by using her composition to navigate to her information resources, and using combinFormation's agents to go to other related sources. In creating her final

deliverable, she refers back to her composition to help her gather information, organize her thoughts, and create a bibliography.

Background

Surrogate

A surrogate represents an information resource and enables access to that resource (Burke, 1999). Hypermedia surrogates, which enable navigation, are formed systematically from metadata. One typical surrogate is the Google gist, an element of the result set returned by a search query. People make critical decisions based on these surrogates, such as choosing which documents to browse, and which to ignore. Other typical surrogates include bookmark, the e-book entry in digital libraries, the ITunes, playlist entry, and the TV guide entry. Surrogates play a major role in keeping found things found (Jones et al. 2002). In combinFormation, the basis of the surrogate structure is the inherent relationship between a clipping and its source document, and also to optional hyperlinked documents.

Image and Text Representations

In the working memory system, the visuospatial buffer, which stores mental images, and the rehearsal loop used for words have been shown to function as complementary subsystems (Baddeley, 1992). They support each other in combined image and text representations. Likewise, research has shown image and text knowledge representations are more effective than text only. For example, cognitive research by Glenberg (Glenberg et al., 1992) establishes that the combination of an image and descriptive text promotes the formation of mental models (Gentner et al., 1983). Thus, combining images and text while forming surrogates makes excellent use of cognitive resources. Since text disambiguates images while engaging complementary cognitive subsystems, combined surrogates provide clearer navigation. Combined surrogates, in which images and text reinforce each other, lead to better comprehension and reduced human processing time.

Collections and Compositions

As evidenced by formats returned by search engines, and those utilized by web browsers for bookmarks and digital audio players such as the iPod for playlists, the list of textual surrogates is currently the format typically used to represent collections. Composition is an alternative to lists; literally, it means, “the act of putting together or combining … as parts or elements of a whole” (Oxford English Dictionary on Compact Disk, 1992). Composition of image and text surrogates extends the organizing of information afforded by spatial hypertext (Marshall and Shipman, 1994). Like spatial hypertext, composition includes arranging and annotating elements in an information space. Our approach differs in its emphasis on visual design and communication, as well as its attention to finding and collecting elements that function explicitly as surrogates. By composition space, we mean the interactive environment in which the process of putting the composition together occurs. The use of collected elements in compositional hypermedia enables the shift to more visual representations, based on images as well as text, without requiring these surrogates to be created anew. The composition space serves as a basis both for the agent’s generative representation of search query result sets and surrounding information, and for users’ authoring of personal collections.

Composition uses visual design techniques, layering and blending elements, to form a coherent whole (Tufte, 1990). In combinFormation, these design techniques include relative size relationships, colors, type faces, text stroking, and image compositing. Stroking dark text with a thin light background guarantees contrast with overlapped elements, while maximizing how much of what is underneath can read through. Compositing is a means for making visible strong connections among elements. It is accomplished through the image processing technique of alpha gradients. This technique renders the border area of an image as progressively translucent. The result is a visual crossfade. Compositing contrasts with the hard edged

juxtaposition of placement without blending. In combinFormation, both the user and the generative agent can create compositing effects.

Information Discovery

By information discovery, we mean not the discovery of information per se, but the use of found information in the context of human experiences in which new ideas emerge. Etymologically, discovery is rooted in processes of "uncovering," it means "bringing to light that which was previously unknown," as well as "exploration, investigation" (Oxford English Dictionary 1992). *Information discovery* tasks begin with finding relevant information resources (Kerne Smith 2004). Users also need to develop understanding of the connections among many diverse information resources. Thus, information discovery involves the emergence of new perspectives and new ideas in the context of the stimulus of found information. Information discovery plays a key role in processes of invention, because these often involve seeing existing materials and prior work in new ways. The Design Process course engages students in creative learning experiences of knowledge creation through information discovery and invention. The present research develops new methods for supporting processes of information discovery, as well as new methods of validation.

Field Study

A field study was conducted to validate the efficacy of combinFormation in promoting information discovery through the mixed-initiative composition of image and text surrogates. Students in an undergraduate course on The Design Process were engaged in the creative learning experience of developing new inventions. In this study, alternating sets of members of the class used combinFormation to create collections of prior work information resources relevant to their new inventions. The two mutually exclusive groups of students were found to do better on the project, itself, when they used combinFormation to develop their prior work collection.

Method and Procedure

In the course, Environmental and Design Science (ENDS) 101/200, The Design Process, there were 182 students in the class, of which 47% were women and 53% were men. Academic majors were distributed, including 44% science and engineering, 33% architecture and liberal arts, and 17% business. The course engages these diverse students in an intensive process aimed at developing creative innovation in design. The assignments in The Design Process course were already structured as information discovery tasks. In one assignment, the Hybrid, students are asked to

'Create the future by combining and connecting any services or objects that have never been linked before and illustrate your new service or idea. Search the Internet and the Patent and Trademark Library to see what the most relevant prior work is, as well as how your idea is original, and to collect the source materials for the existing services and objects that are being combined.'

The description of a second assignment, the *Invention*, begins, 'From your group's creative depths, journals or a posted Bug List, create at least three original inventions.' The assignment continues with the same prior work collection requirement.

This was a real class, and not a controlled laboratory experiment environment, so we couldn't arbitrarily assign students to conditions in a way that was unfair. Therefore, we developed a method in which groups of students alternated using combinFormation for developing their prior work collections. For the first assignment, half of the students in the class were asked to volunteer to use combinFormation; in the second assignment, the other half of the class was asked to use the systems for representing their prior work collections as compositions of image and text surrogates.

	cF	Google+Word	not involved	total / average
# of students	59	88	35	182
% of students	32.4 %	48.4 %	19.2%	100%
prior work	3.08	2.32		2.63
Hybrid	3.32	2.85		3.04

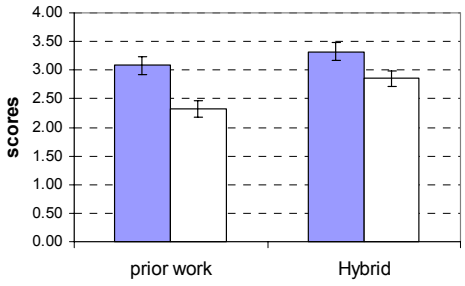

Figure 2: Student scores on the Hybrid assignment

	cF	Google+Word	not involved	total / average
# of students	61	98	23	182
% of students	33.5 %	53.9 %	12.6%	100%
prior work	3.13	2.38		2.66
Invention	3.41	2.85		3.06

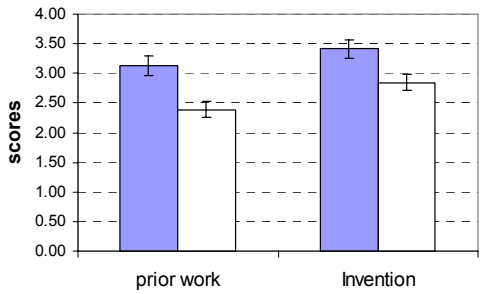

Figure 3: Student scores on the Invention assignment

In keeping with the ethical needs of the course, participation was not mandatory. Across the two assignments, two thirds of the students elected to participate by using combinFormation on one of the assignments. The groups of students that used combinFormation on the two assignments were mutually exclusive. Those students that did not use combinFormation used Google for searching, and Word for representing their results in the form of a traditional bibliography (Google+Word). For both assignments, we investigated both how the students performed on prior work collection development, and how they performed on the inventive deliverables.

Data and Results

We worked with the professor and teaching assistants for The Design Process course to develop evaluation criteria for evaluating both the collection deliverable, and the project itself. These criteria articulate the values of the course, and the evaluation process that was already in place. Additionally, a new 1-5 scale was instituted for the study. This scale corresponds directly to the letter grades that are assigned in the course. For the prior work, the criteria involve how informative, communicative, expressive, the collection is, as well as the variety of the collected resources. For the actual inventions, they involve originality, novelty, practicality, broad impact, and commercial transfer ability. While these measures are in some sense subjective, they are directly correlated and integrated with the evaluation process of the course. The evaluations were performed by the TAs as they were assigning grades based on the same criteria.

Approximately 81% of the students performed the Hybrid assignment (See Figure 2). 32.4% used combinFormation to develop the prior work collection, and 48.4% used Google+Word. Those who used combinFormation scored an average of 3.08 on the prior work, compared to 2.32 for those who used Google+Word, and the difference was significant [$t(118) = 3.528$, $p = 0.001$]. Likewise, those who used combinFormation also scored higher (3.32 vs. 2.85) on the actual Hybrid assignment, and again, the result was statistically significant [$t(145) = 2.227$, $p = 0.028$].

The findings were similar for the Invention assignment. This time, 33.5% of the students used combinFormation, out of a total of 87% who did the assignment (See Figure 3). None of these were students who used combinFormation on the Hybrid. 53.9% used Google+Word for creating their prior

work. The scores for the prior work collection were 3.13 for the combinFormation users vs. 2.38 for Google+Word [$t(141) = 3.843$, $p < 0.001$]. For the actual Invention, the scores were 2.85 vs. 2.38 [$t(157) = 2.716$, $p = 0.007$]. The score differences of both for the prior work and for the actual invention assignment were statistically significant.

From the field study, we found that combinFormation better supports students engaged in collecting and putting together prior works. According to the scores, the T.A. has found that representations of collections assembled in the medium of composition of image and text surrogates are better than textual lists for understanding, developing ideas, and the communication of meaning. Further, subsequent to developing prior work collections with combinFormation, students performed better on the actual Hybrid and Invention assignments than those who used Google+Word.

Discussion

We are just beginning to deploy combinFormation in The Design Process Course, and gather data from students about their practices and needs, and how the interactive system can serve them better. One finding is a need to improve the responsiveness of the agent, to enable more focused information retrieval, and more meaningful forms of generative composition. Another is the need for direct manipulation design features, such as grouping. Additionally, there have been some difficulties with field deployment, involving memory allocation by the Java Plug-in when invoked inside the Internet Explorer web browser.

In light of these shortcomings with the present deployment of combinFormation in The Design Process Course, we are particularly encouraged by the results of the present field study. Our explanation is that using the interactive system for collecting relevant information, and representing the collection as a composition of image and text surrogates stimulates the students to think about possibilities for their hybrids and inventions that are outside of the realm of what they would otherwise consider. Adding the temporal dimension to visual composition increases the set of information resources that the user is exposed to. The use of complementary image and text surrogate representations promotes cognition of this larger set of representations. Additionally, the accessibility of these surrogates in the composition space enables quick expressions of interest, which tune the semantic model, and thus the performance of the agent, to retrieve information that is more relevant to the user's emerging sense of the invention process. This traversal of a wider emergent space of relevant possibilities promotes information discovery; students create better hybrids and inventions.

Our future work includes conducting laboratory experiments to discover how particular features in combinFormation contribute to creative experiences and the production of new knowledge. Further, we will research and develop new forms of visual representation and semantics, support for digital libraries such as patent repositories, and interactive mechanisms to improve system support for users engaged in processes of knowledge creation. We will integrate these findings with new pedagogical approaches for stimulating students' creative experiences in educational environments.

References

Baddeley, A.D. (1992). Is working memory working?, *Quarterly Journal of Exp Psych*, 44A, 1-31.

Burke, M. (1999). *Organization of Multimedia Resources, Hampshire*, UK: Gower.

Gentner, D., Stevens, A.L., eds. (1983) *Mental Models*, Hillsdale, NJ: Erlbaum, 99-129.

Glenberg, A.M., Langston, W.E. (1992). Comprehension of illustrated text: Pictures help to build mental models, *Journal of Memory & Language*, 31(2):129-151, April.

Horvitz, E. (1999). Principles of Mixed-Initiative User Interfaces, *Proc CHI 1999*, pp. 159-166.

Interface Ecology Lab (2006), combinFormation, http://ecologylab.cs.tamu.edu/combinFormation/

Jones, W., Dumais, S., Bruce, H. (2002). Once found, what then?: a study of 'keeping' behaviors in personal use of Web information. *Proc ASIST 2002*, November 18-21, 391-402.

Kerne, A., Smith, S., The Information Discovery Framework, *Proc ACM Designing Interactive Systems (DIS) 2004*, 357-360.

Marshall, C.C., Shipman, F.M. (1994). VIKI: Spatial hypertext supporting emergent structure, *Proc ECH*, 13-23.

Oxford English Dictionary on Compact Disk (1992), 2nd Edition. *Oxford: Oxford University Press*.

Pew Internet & American Life Project (2002), The Internet Goes to College, http://www.pewinternet.org/pdfs/PIP_College_Report.pdf

Tufte, E. (1990). *Envisioning Information*, :Cheshire, Connecticut: Graphics Press.