Connecting Interface Metaphors to Support Creation of Path-Based Collections

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Abstract. Walden's Paths is a suite of tools that supports the creation and presentation of linear hypermedia paths—targeted collections that enable authors to reorganize and contextualize Web-based information for presentation to an audience. Its current tools focus primarily on authoring and presenting paths, but not on the discovery and vetting of the materials that are included in the path. CollageMachine, on the other hand, focuses strongly on the exploration of Web spaces at the granularity of their media elements through presentation as a streaming collage, modified temporally through learning from user behavior. In this paper we present an initial investigation of the differences in expectations, assumptions, and work practices caused by the differing metaphors of browser based and CollageMachine Web search result representations, and how they affect the process of creating paths.

1 Introduction

Collections of digital materials are significant communicative artifacts in digital libraries, both for collections established by a formal organization [5], but also for collections kept for the purpose of organizing materials into an individual's personal information space [16]. Collection building and management software, like VKB [13], Hunter Gatherer [10], or Collector [16], which aids end-users in creating digital library collections [16], support various structures for user collections; for example, bookmark lists and file systems support tree-like structures, VKB supports stacks, lists and composites, while the Collector uses Greenstone-specific storage and access structures. Our own system, Walden's Paths [11], supports linear paths of items, perhaps the easiest form to create, understand, and convey to others.

Hypertext-based paths have a long history, beginning with Bush's memex [1], and including Trigg's Guided Tours and Tabletops [15], and Zellweger's Scripted Documents and Active Paths [17]. In Walden's Paths, paths are collections of World-Wide Web material used to communicate information from path authors to path readers. Earlier we reported on use of paths in an educational setting, where teachers used paths to express curricular concepts and achieve academic goals [3, 11]. These path authors relied on Web search engines to locate relevant information. They devoted exhaustive time to searching and locating pages for inclusion in the paths, following every link that was even remotely interesting to explore the information it contains. Unfortunately,

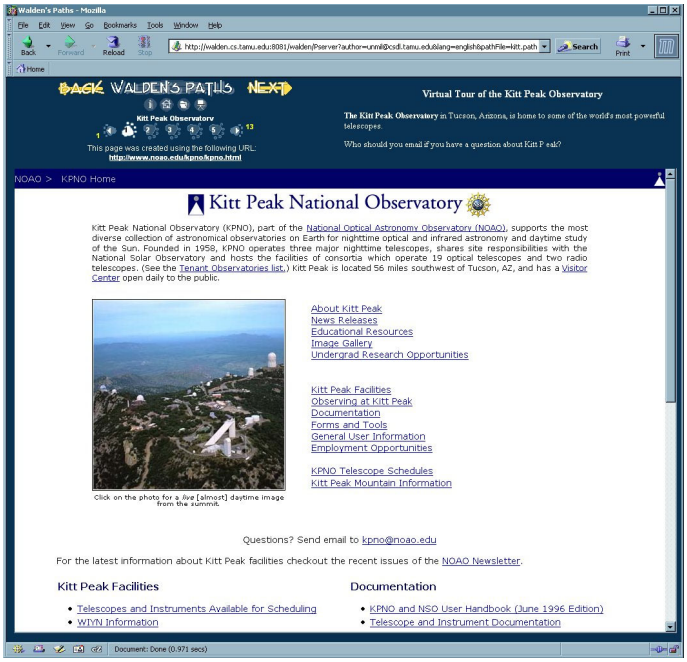

Fig. 1. The Path Server, the path viewing interface

keyword-based searches do not return pages that may use conceptually similar but syntactically different terms. Further, the authors' understanding of their problem space is emergent—as they add information to their paths, they get a better sense of additional pages that must be included in the path, resulting in modification of the original search. Consequently, the traditional search engine sometimes became cumbersome. This led us to explore alternative work practices for collection creation.

CollageMachine [6–8] addresses some of the above issues. It starts with a user-specified seeding (for example, search terms or Web addresses) that reflects the user's interests and retrieves matching information from Web. It then extracts information elements from these pages and streams them to a continuously evolving canvas to build an active collage. It also crawls the space and presents information from linked pages. Users may participate in the creation of the collage by interacting with elements that they like and cut those they dislike. It supports emergent behavior by learning from user actions. However, user interaction is not necessary as the collage continues to evolve even when a user takes a break to do other tasks. Such a tool provides the opportunity for a very different work practice during collection creation—one where the user is actively engaged in managing existing resources while at the same time peripherally monitoring CollageMachine for potential additions to the collection.

In this paper we explore the effects of using CollageMachine as an information forager for creating paths. We present the observations of a preliminary study and discuss how these inform the system architecture for co-use of the path authoring tool with Col-

lageMachine. We specifically focus on the practices of experienced Web searchers and how these result in behavioral expectations from CollageMachine.

We introduce Walden's Paths and CollageMachine in the next two sections. Section 4 presents our observations of users who developed paths using CollageMachine and Google [4] to locate information. Sections 5 and 6 discusses our observations, their implications for system design, and research directions for the future.

2 Walden's Paths

Walden's Paths [11] facilitates use of Web-based information collections, where the collection author usually is not the Web page author. This is achieved through paths: Web-based, linear meta-documents (documents whose contents are other documents). In implementation, paths consist of a sequence of *stops*, each of which presents a Web page and an annotation. Annotations, therefore, aid path authors in providing a rhetorical structure that recontextualizes Web-based information from possibly disparate sources.

Readers may view paths via the Path Server using recent versions of standard Web browsers with the interface shown in Figure 1. The stop's Web page, as it would be displayed without the mediation by Walden's Paths, is displayed at the bottom. The annotation or contextualizing text added by the path's author is at top right. The top left portion contains the controls for navigating along the path. Readers may view the stops on the path in order by clicking on the "Next" and "Back" arrows or they may jump to any stop on the path by scrolling to and clicking on the corresponding "paw." Readers can follow links on pages at any time to freely examine the information space. While the reader is browsing off the path, the controls are replaced by one that links back to the last page visited on the path, thus providing an easy way to return to the path.

The process of path authoring starts with concept development. Authors need to begin by forming a sense of what they want to communicate, who the intended audience is, and how Web resources will be involved. Then, more specifically, they must [12]: Locate promising Web sites; Browse and evaluate materials at these sites; Select information elements for use in the path; Develop an outline for the presentation; Place and order stops within the sections of the path; and Write the introductory text and annotate the stops. This list is not intended to imply that steps must be followed a strict order or that all of them will be carried out in all authoring situations. For example, a path author who uses his own Web pages does not need to search for or evaluate the materials. However, when information is retrieved from the Web via search tools, the author must ascertain its veracity and relevance to ensure the integrity of the path. The current Walden's Paths authoring tools support only the last three steps, assuming that authors will use separate search engines and Web browsers in carrying out the first three tasks.

The PathAuthor is a stand-alone Java application. Figure 2 shows a snapshot taken during path authoring. This shows the interface used to create and edit the path specification. This interface displays information about the path as a whole, i.e., the path title and list of stops in the path, and includes controls for reordering the stops by shifting them up or down. The Path Preview feature enables authors to get a reader's view of the path without requiring them to connect to the Path Server. The PathAuthor also contains controls for working at the page level. An author may create new stops, delete

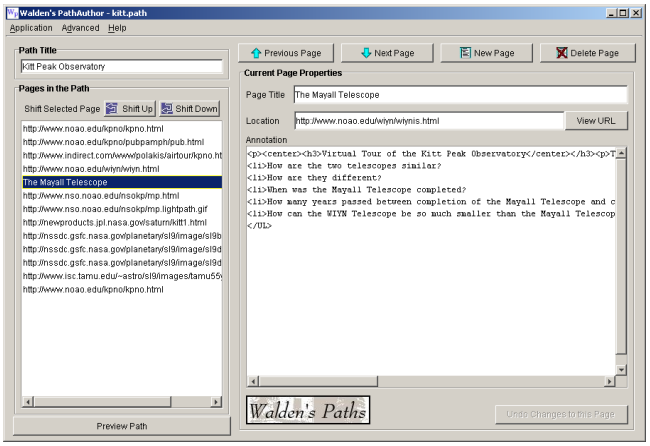

Fig. 2. The PathAuthor

the currently active stop, or edit the contents of the current stop. The active stop may be changed by clicking on the desired stop in the stop list or by using the “Previous” or “Next” stop buttons. For each stop, the author may provide a title, the Web location, presumably retrieved from a Web search engine, and the contextualizing text for this Web page. The URL of a Web page can be dragged from a browser and dropped into the PathAuthor “Location” field, copy and pasted, or typed in directly.

Finding resources traditionally has relied on Web search engines, e.g., Google [4]. These use the now familiar keyword and result list metaphor, where users provide the keywords or key phrases of interest and the search engine responds with a list of links to Web pages. Inherent in the metaphor is the temporal separation of query and result—search engines perform a one-time search for the specified keywords and preferences and return the list of matching pages leaving the user to browse through these, opening pages that may seem interesting or relevant. Returned results do not initiate a behavior without user action. The transaction unit is a Web page, thus the search engines can be said to work at page granularity. In contrast, CollageMachine embodies a continuous browsing metaphor at the granularity of information elements.

3 CollageMachine

CollageMachine [6–8] is a generative Web visualization tool that encourages Web space exploration. New ideas emerge through open-ended processes of exploration with preinventive representations [2]. The result list metaphor for interaction with Web search results is effective when one knows what one is looking for and how to specify it. However, in cases where either the goal or effective keywords are still in formation, the need to click through many links becomes a burden. The visual combinations of information elements that CollageMachine generates afford exploratory interaction.

CollageMachine affords browsing not at the Web page level but at the finer-grained level of media elements—components of pages such as images, chunks of text, videos,

Fig. 3. Collage session seeded with Web pages from the NSF Digital Libraries Initiative Phase 2.

sounds, etc. Collaging begins with a set of seeds, in the form of Web addresses. Seed addresses may be entered directly, may result from search queries, or may be dragged from pages being viewed in a Web browser. Seeds may be specified at any time, either initially or during the course of a session. CollageMachine uses the seeds to download pages and then breaks them down into their constituent media elements, maintaining internally a model of their referential hypermedia graph structure. The media elements are presented to the user in a dynamically evolving collaged presentation that updates continuously as the hypermedia graph structure is traversed. Figure 3 displays a snapshot of an ongoing collage session. In the figure, the cursor is positioned over an image element in the upper left hand corner. In this rollover state, CollageMachine displays metadata about the image, and also about the container of its origin.

CollageMachine provides means for the user to affect its presentation. The design tools (see Figure 3, bottom center) enable the viewer to perform operations such as cutting, dragging, and resizing of collage elements. Elements can be dragged both within the collage but also out to other applications, such as traditional Web browsers. (As an accelerator, when the Web page tool is active, clicking on an element opens the contextualizing Web page in a traditional browser window.) The design tools allow the viewer to express interest, or disinterest, in displayed elements. A model of user interests is

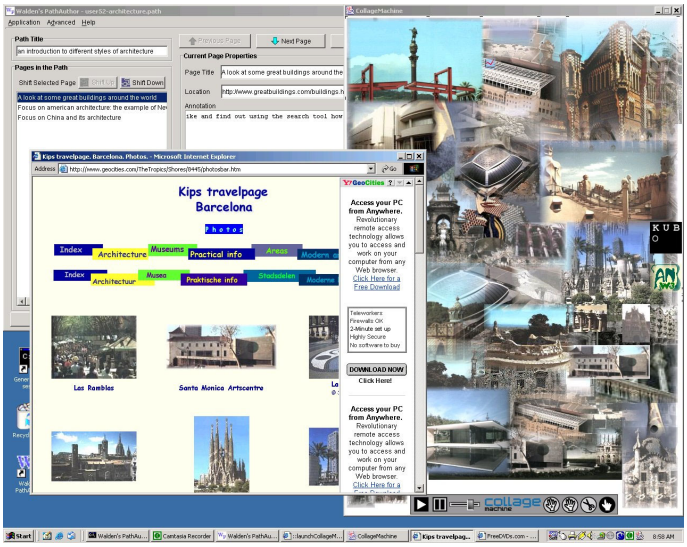

Fig. 4. Authoring paths while browsing with CollageMachine

built from these actions. Interest is propagated from the initial element to related ones by spreading activation [9]. When the user interacts with a collage element, this affects the program's determination of related material, modifying the subsequent choices of elements to present.

This model of interests serves as the basis for all of the program's collage-making operations. Automatic browsing can get noisy quickly if the program's procession is purely random since beyond the initial seeds there is no a priori knowledge of which hyperlinks are relevant. The model also guides decisions about the sizes and shapes of new media elements that enter the collage, and which already visible elements to cover.

Collage works by creating new assemblages of found objects. These new formations can challenge our internal representations, and thus stimulate the formation of new ones. CollageMachine is designed to support mixed-attention use; that is, sometimes one gives it full attention: interacting with the compositions by grabbing elements of interest that show up, and engaging in expressive collage design. At other times, the user can let the evolving collage slip into the ambient periphery, while giving attention to other activities. This supports creative processes such as divergent thinking and incubation [2] that can lead to the emergence of new ideas. It is the process of going away and returning that helps create new internal structures of representation that enable insight. Peripheral sensing of the evolving stimulus of the collage facilitates incubation.

4 Pilot Study

To gain an understanding of the differences in the processes, expectations and practices caused by the use of different information-finding metaphors we conducted a pi-

lot study, observing users as they created paths using resources discovered with CollageMachine and with Google.

The user pool consisted of seven individuals with at least a baccalaureate degree, most with a master's degree, in a variety of science and social science related fields. All had some teaching experience, as graduate teaching assistants or as teachers in local school districts. They were conversant with browsing and searching on the Web. None had worked with either Walden's Paths or CollageMachine before the evaluation; however, some were familiar with Walden's Paths at a conceptual level.

The users were randomly assigned to one of two pools. One pool searched the Web with CollageMachine to locate resources for paths, while the other searched with Google. Since CollageMachine uses Google to convert queries into an initial set of Web pages, the tasks differ only in the paradigms for presenting and browsing results.

We requested two-hour time slots from the users, but informed them that the tasks were not timed and that they could take as long as they wanted to accomplish them. Most users actually took closer to three hours in completing the tasks. We observed the users while they worked, but did not interrupt with questions or comments. Since we wanted to understand the problems faced by users, we answered their questions, either conceptual or operational, at any time during the path authoring session.

The users first answered a demographic questionnaire and received a brief introduction to the study tools. We then asked each user to author two paths, the first on a topic that we selected that was unfamiliar to them and the second on a topic of their choice that they might teach in a class. Because CollageMachine emphasizes the visually appealing aspects of Web pages, we ensured that the topics we selected were visually rich, for example, French painting, introduction to architecture, and tourism in Africa. In both tasks, the users were left free to choose the length and the nature of the path.

We displayed the PathAuthor on the left and the search tool on the right so that initially none of the applications was completely obscured by another. Figure 4, a screen captured from a user session, displays the unmodified position of these applications along with the Web page display of one of the collage elements. The PathAuthor and CollageMachine were instrumented to generate logs of user actions and we captured all screen activity to get the overall context of the actions. The screen capture was especially important, as we were not able to obtain logs of user interaction with Google. After authoring the paths, users completed a post-activity questionnaire. Finally, we asked them about their experience with the tools and shared some of our observations to get their inputs in a free-form audio-recorded interview.

Users displayed an active interest in learning the tools. During the short training provided, they asked questions to clarify concepts and operations. While CollageMachine's concepts evoked some initial surprise, they liked the variety of operations that could be performed. They especially liked the grab tools and used positive as well as negative grabs to try and guide CollageMachine to objects that interested them. Some users (but not all) discovered CollageMachine's contextualizing metadata as they let the mouse hover over the media elements and used this feature to avoid visiting sites whose names did not interest them. At other times, users were taken by the visual appeal of the elements and while the element was clearly orthogonal to the topic of their path, decided to visit the containing pages out of curiosity. A user who was creating a path

on 17th century painting could not resist the urge to visit a page that contained a picture of a little boy in a modern firefighter's suit.

As in an earlier study [3], users seemed to grasp the concepts of paths and the process of creating paths quickly, getting off to a running start with the PathAuthor once its features were explained. Users created paths that were diverse in length (between three and twelve stops long) that varied substantially in focus as well as nature. Some created paths to aid classroom-teaching sessions for specific topics, e.g., Mitochondrial DNA, Basic Concepts in Ecology, and Leatherback turtles. Others developed paths that provided an overview and resources for a semester-long course (Introduction to Robotics). Yet others developed resource lists that targeted a variety of audiences, including a resource list for Chinese Recipes.

Users who searched with Google were familiar with the metaphor, the process, the interface, and the interaction. However, CollageMachine users, who were exposed to a completely novel information location paradigm, took some time to adjust to the tools, typically taking more time to create the first path than to create the second, both being of comparable lengths. The paths created with CollageMachine tended to use more pages from a Web site than those created with Google. This could be because CollageMachine not only explores Web pages returned by the keyword search, but also crawls to pages linked from them. The linked pages may not contain the user-specified search terms, but may explicate a topic related to the path. Thus, CollageMachine was aiding users by assuming some of the responsibility for "browsing" off of the initial search results.

As expected when confronted with a tool supporting an alternative work practice, CollageMachine users tended to judge the software based on expectations more appropriate of a search engine. Some of the users were confused by the initial delay in viewing results while CollageMachine was mining pages and extracting elements for display and feared that it had not found anything of interest or that they had specified incorrect query terms. Others thought that the element display delay wasted their time. One user felt that Google was better because it presented her with multiple Web pages at a time that matched the search criteria and she could choose to go to a particular page or Web site and ignore the ones that did not interest her. Many comments regarding CollageMachine focused on the relevance of the search results returned. As the elements in the Web pages were displayed out of context, users had some trouble putting them back in the context without having to view the page that contained each image or chunk of text. Pages that were more descriptive or illustrative generated more elements for display and the users had little control over the decision to display these. The users expected CollageMachine to reflect the grab cues depicting their interest instantly and not display additional elements from these pages.

One of the features we expected to be of use remained virtually unused. We showed users that dragging a collage element into the location bar of the PathAuthor copied the location of the Web container of the element into the location bar. Instead, users preferred to click on CollageMachine elements, bringing up the enclosing page in a Web browser, and then drag the location of relevant pages from the *browser* into the PathAuthor's location bar. It appears that they were interested in knowing the original context of the elements in the Web pages before deciding whether to include it in their paths.

5 Discussion

Users requested additional features in the PathAuthor and CollageMachine. Users requested a work area in the PathAuthor where they could store pages that seemed interesting for possible future use. While the users who searched with Google were reasonably certain that they could find the page again if needed, users of CollageMachine were anxious to save the pages that they had found, lest they could not reach it later.

Drag-and-drop semantics in the realm of collage elements raise questions. One user wished to drag an element (not the Web page containing it) into the PathAuthor, thus making the stop point to the image. This raises the question of what drag-and-drop semantics should be when applied to collage elements. A collage element, unlike text in browsers or a Web location, is a complex entity. The element is represented by an interface (the image or text), points to its container, and accepts certain actions from the user, such as clicking on it to open its containing Web page. Further, the interface that the element presents is a sample, rather than a complete representation of the element—for example an image may be scaled or text abstracted. When an author drags an element from CollageMachine into the PathAuthor, the action may have several possible interpretations. The user may wish to include the Web page that contains the displayed element or, equally possible, may wish to include the image itself, or indeed the abstracted form. Thus the simple action of dragging an element may have multiple connotations.

CollageMachine uses indeterminacy—that is, structured randomness—in the selection of elements for creating the collage [7]. The path authors tended to express that there was not enough connection between their design actions in the collage space, and the results of what media CollageMachine retrieved and displayed. This was hinted at via comments about the unpredictable nature of the elements that CollageMachine would show. They were also concerned about CollageMachine not acting on their grab directives in a predictable manner. This indicates both that CollageMachine users need richer tools for expressing their intentions, and, more fundamentally, that the program's model of the user's intentions must be more effective in representing the user's intentions based on their expressive actions, and making selection and composition decisions based on these expressions. When there is the right level of structure, the indeterminacy will effectively serve to create openness and variation.

The users who participated in the evaluation were conversant with the traditional Web search/results paradigm, and unfamiliar with CollageMachine. This is reflected in their expectations of CollageMachine as well as their work practices. The authors interacted with the browser as much as possible, treating CollageMachine as a search interface alone, using it simply as an area to look for interesting pages, quite akin to the lists of search results returned by Google. We expect that as users become familiar with the collage browsing metaphor, they may exhibit more collage-centric behaviors.

Some users feared that if they did not devote their attention to the developing collage, they might miss out on information, causing their paths to be less effective. Similarly, some users expressed the need to stop the developing collage when they were working with the PathAuthor. Again, this is an issue of paradigm familiarity that we expect would diminish with further experience.

Some users were not comfortable dealing with the recontextualization that results as CollageMachine deconstructs Web pages and assembles their constituent media ele-

ments. A media element's original context can be important in determining if it fits in a path intended for a specific set of readers. Users demonstrated their interest in the element's context by viewing the containing Web pages for elements that interested them. One user, who had not yet discovered collage element rollover state, commented about the lack of element context: "I saw an interesting picture, viewed and added the page to my path. The next few pictures gave me the same page again and again...." CollageMachine's display of multiple images from a relevant page confused this user who, from past experience with Web search engines, assumed that they must all be from unique pages. Viewing the rollover information would have alerted the user that these images came from a single page. Enhancing the notion of context in CollageMachine, as well as better communication of its operational model, would help here.

6 Conclusion

We observed that authors who started with a sketchy notion and were flexible regarding the contents of their paths appreciated CollageMachine. On the other hand, authors who mentally crystallized the flow and contents of their paths before starting were frustrated by lack of a deterministic response to their specific queries. Due to its structured indeterminacy, CollageMachine presents itself as an attractive option for path authors when they are flexible about the contents of the paths they create within their domain of interest. CollageMachine may serve as a more suitable foraging tool for paths that have fewer constraints. A few examples include paths that do not target specific grade levels or age groups, and paths that are not rhetorically intense, for example, resource lists. CollageMachine may also serve as an effective tool to explore the authoring space for a particular topic before deciding the structure of the path. As an exploration tool, the author may seed a collage with general query terms and let the collage develop for a while, with periodic interjection to keep the collage from wandering too far off topic. Most importantly, mixed-mode environments, in which different tools for the presentation and building of collections are available concurrently, will let users match interface metaphors to the mental models and activity at hand.

The integration of CollageMachine and PathAuthor raises fundamental issues about the activity of collection building. Collection building is a creative process. In this, it differs markedly from well-defined tasks, such as simply looking up train schedules, stock prices or API specifications (though links to all of these materials may end up in a collection). Browsing/searching for something known is essentially an information location activity. Collection building is a kind of authoring, a process of formation that draws from intuition.

Although path authors start with a certain sense of what they are looking for, this sense is likely to evolve through the course of path formation. What is found in the process influences the sense of what is being looked for. External factors, such as feedback from independent sources, may also influence the evolution of concept and path formation; indeed it may modify the very definition of the path's subject. Incubation [14] refers to the way mental models evolve when one is not directly working on concept and strategy formation. Sometimes, insight comes when we go away and return. One explanation is that new inputs create new perspective that allows our internal representations

to re-form. Return after absence can thus be part of the evolution of insight. In short, feedback both from the authoring process itself, and from other processes, including internal cognitive ones, and communication with other sources, all have an effect. Tools that intend to support collection building need to consider the different processes that are involved, and support them.

Another aspect that arises is that users do not necessarily have a strong sense of the issues involved in collection-building, even though they have great need to keep track of stuff they encounter while browsing. Their exposure to tools for collection building is limited. Typical users have exposure to browsers, and their favorites mechanisms. They have word processors, into which elements can be dragged. As Schraefel points out [10], word processors are particularly weak for collection building. The problem is that while they support the collection of media elements, they don't automatically enable keeping track of the Web page container from which each element is drawn. The connections of elements to their contextualizing containers are essential.

The observations of the authoring process with CollageMachine and Google has begun to provide us with insight into issues that path authors encounter with respect to the tools and their operation, as well as their cognitive processes. Authors' practices are shaped both by their current tools, but also by their past experiences. The features of existing tools create expectations for newer tools to fulfill. The users were familiar with drag-and-drop as well as the copy-paste actions and these posed no problems for them. On the other hand, they were familiar with exploring search results via resource lists and shifting gears to browse search results via temporal collages did not map easily to their expectations. The users were aware of this fact and expressed that they could get used to browsing collages with some practice. This highlights needs in three overlapping areas: communicating with users, understanding and addressing the conceptual and usability issues that arise in the new environment, and reconciling the expectations of authors with the expectations of the tools. Paradigms do not shift all at once. Users will gain perspective on collection-building through exposure to a rich set of metaphors. Design needs to be based on a combination of the needs that users articulate now, and from developers' imaginations [8] of how practice can be transformed.

The pilot study focused on observing how users create paths and understanding their motivations, needs, and practices. We intend to enhance the PathAuthor and CollageMachine by developing the features requested by the authors and modifying the existing tools to better suit the motivations and work practices of the authors. We also intend to test the authoring of paths with users who are familiar with CollageMachine and train other users to work effectively with it. The work practices of the authors and changes after training, if any, will yield further clues about the facets of the collection building process.

The "search, examine, then add" practice of collection building has developed as people became comfortable with search engines over the last decade. While the study reinforces the fact that users tend to take new tools and fit them into existing work practices, it also provides examples of other forms that collection building might take. In the end, path authors and other collection builders should have tools supporting a variety of work practices, including both directed search and peripheral browsing. Towards this end, we will build environments in which users can choose different interface

metaphors to support their changing cognitive processes and continue to identify cognitive, semantic, interface design, usability, and architectural issues that arise in the process of connecting metaphors during collection building.

Acknowledgements

We thank the users who participated in the pilot study. This material is based upon work supported by the National Science Foundation under grant numbers DUE-0085798, DUE-0121527 and IIS-0219540.

References

1. V. Bush. As we may think. *The Atlantic Monthly*, pages 101–108, Aug. 1945.
2. R. Finke, T. Ward, and S. Smith. *Creative Cognition*. MIT Press, Cambridge MA, 1992.
3. R. Furuta, F. Shipman, C. Marshall, D. Brenner, and H. Hsieh. Hypertext paths and the World-Wide Web: Experiences with Walden's Paths. In *Proceedings of Hypertext'97*, pages 167–176. ACM Press, Apr. 1997.
4. Google. http://www.google.com/ (accessed January 2003).
5. Institute of Museum and Library Sciences. A framework of guidance for building good digital collections. http://www.imls.gov/pubs/forumframework.htm (accessed January 2003).
6. A. Kerne. *CollageMachine: A Model of Interface Ecology*. Ph.D. dissertation, New York University, 2001.
7. A. Kerne. CollageMachine: Interest-driven browsing through streaming collage. In *Proceedings of Cast01, Living in Mixed Realities*, pages 241–244, Sept. 2001.
8. A. Kerne. Concept-context-design: A creative model for the development of interactivity. In *Proceedings of the ACM Creativity and Cognition Conference*, pages 192–199, 2002.
9. G. Salton and C. Buckley. On the use of spreading activation methods in automatic information retrieval. In *Proceedings of SIGIR 1988*, pages 147–160, 1988.
10. M. Schraefel, Y. Zhu, D. Modjeska, D. Wigdor, and S. Zhao. Hunter Gatherer: Interaction support for the creation and management of within-Web-page collections. In *Proceedings of WWW 2002*, May 2002.
11. F. Shipman, R. Furuta, D. Brenner, C. Chung, and H. Hsieh. Guided paths through Web-based collections: Design, experiences, and adaptations. *Journal of the American Society of Information Sciences (JASIS)*, 51(3):260–272, Mar. 2000.
12. F. M. Shipman, R. Furuta, and C. C. Marshall. Generating Web-based presentations in spatial hypertext. In *Proceedings of International Conference on Intelligent User Interfaces*, pages 71–78. ACM Press, Jan. 1997.
13. F. M. Shipman, H. Hsieh, R. Airhart, P. Maloor, J. M. Moore, and D. Shah. Emergent structure in analytic workspaces: Design and use of the visual knowledge builder. In *Proceedings of Interact 2001*, pages 132–139, July 2001.
14. S. M. Smith and S. E. Blankenship. Incubation and the persistence of fixation in problem solving. *American Journal of Psychology*, 104:61–87, 1991.
15. R. H. Trigg. Guided tours and tabletops: Tools for communicating in a hypertext environment. *ACM Transactions on Office Information Systems*, 6(4):398–414, Oct. 1988.
16. I. H. Witten, D. Bainbridge, and S. J. Boddie. Power to the people: end-user building of digital library collections. In *Proceedings of the first ACM/IEEE-CS joint conference on Digital libraries*, pages 94–103, June 2001.
17. P. T. Zellweger. Scripted documents: A hypertext path mechanism. In *Proceedings of the Second ACM conference on Hypertext*, pages 1–26, Nov. 1989.