A Multiscale Workspace for Managing and Exploring Personal Digital Libraries

Daniel Bauer
Distributed Cognition and HCI Lab, Cognitive Science Department
University of California, San Diego
9500 Gilman Drive, La Jolla, CA 92093-0515
dsbauer@cogsci.ucsd.edu

ABSTRACT
People interact with personal information collections in two closely-related ways: managing – organizing, indexing, culling, and assimilating new items – and exploring – browsing, filtering, and reflecting on the contents as part of a concernful activity. Managing and exploring a collection are not independent activities; many interactions serve both purposes.

Existing work has explored the use of images in spatial layouts to represent and interact with collections of several content types, especially digital photos and web-page bookmarks. The broad goal of this research is to extend the use of images and spatial organization to managing and exploring collections of other types, and to better understand the interdependence of these two activities.

In particular, professional researchers maintain personal collections of domain-relevant documents – personal digital libraries – as an essential part of their professional lives. Indeed, the very process of research requires managing and exploring such resources. This work is an attempt both to facilitate and to better understand the use of personal libraries by developing a multiscale image-based workspace for exploring and managing collections of documents.

INTRODUCTION
People maintain personal collections of many types of digital information: photos, media clips, web bookmarks, news articles, email, academic documents, and other files. Yet while we easily acquire such information, we must invest considerable effort to keep it organized in order to find what we need.

One well-known strategy for managing information is to index items with metadata and retrieve them via queries. But not only does effective indexing require significant effort, this index-and-retrieve strategy is inadequate for many of the ways we use collections. Very briefly, its problems are twofold: the indexed categories and attributes may be inadequate to describe what we want, and we may not even know what we want until we see what we have.

Many activities in which these problems arise are better characterized not as “information retrieval,” but as “reflection in action” [14, 9], or as “sensemaking” [13], in which understanding a body of information or a set of representations (like a collection) emerges only through exploring and interacting with it. So the activities of managing or organizing a collection and of exploring or using it are often inseparable.

For example, suppose you amass a large collection of digital photos during a period of traveling, and you decide to commemorate your trip in a web site, featuring a selection of those photos. Most likely, you would begin not by recalling and retrieving specific photos but by browsing the collection – seeing what you have – to remind you of interesting sites and episodes and to cull samples from each. Of course, some retrieval tools could assist this activity, and it would be helpful if your photos were indexed. Metadata might be automatically generated with each photo (e.g. time and location, by a GPS-enabled camera) or inferred from the image itself. But many of the labels which might prove important could be generated neither automatically nor a priori, but only through a process of reflective browsing.

As another example, consider the keywords which categorize all ACM papers (like “Visualization” for this paper). Once the keyword lexicon is established, an isolated paper may be categorized and indexed by those terms. But such categories are developed only in long-term (and collaborative) consideration of the collection as a whole – by understanding each of thousands of papers individually, identifying connections between them, deciding which fit within the boundaries of the domain (or even renegotiating those boundaries), and continually regrouping the accepted members. As with the photo collection, not merely the retrieval but the creation of metadata requires a process of exploration and reflection.

Reflective interaction is equally important in the process of design. For example, Nakakoji et al. observed writers composing text documents within the ART environment [9] and characterized that composition process as a tight iteration of three sub-activities:

Building: writing and editing text fragments which express component ideas;
Reflecting & Arranging: observing relations between fragments and spatially organizing them to reflect those relations;

Integrating: reworking fragments and transitions into a coherent and attractive document.

While word-processing and text-editing environments offer considerable support for Building and Integrating, few tools offer much help with Arranging beyond linear positioning. ART’s 2-D ElementsMap is an attempt not only to support non-linear arrangements, but to elicit “arranging behaviors” which make more visible the “Representational Talkback” [16] which is otherwise implicit.

This description of the writing process illustrates that it involves not merely constructing a document, but refining one’s understanding of the written ideas. The emergence of the written artifact is closely coupled to the emergence of the author’s conceptual model; the activity of composing is also one of understanding.

Consider a final example, a blend of those above: the annotated bibliography. A bibliography is not only a collection of documents but a document itself, whose organization and annotations can be made to reflect relationships between its citations. Composing a bibliography requires browsing, culling, and reflecting on a set of candidate elements, like a photo collection or the ACM corpus.

The activity substructure of bibliography-writing can be depicted as strikingly parallel to Nakakoji et al’s subtasks:

Building: discovering and reading potentially relevant documents;

Reflecting: observing relations between documents;

Integrating: categorizing, annotating, and cross-referencing documents to represent those relations.

Of course the process is iterative: reading, reflecting, categorizing, and annotating may lead the author to discover and assimilate additional citations.

Typically in bibliography-writing, as in other document writing, the activity of Reflecting remains implicit. But like the ART system [9], a workspace which affords spatial arrangement can both facilitate and illuminate Reflecting by coupling it with Arranging.

Constructing an annotated bibliography is a microcosm of the broader activity of research: a continuous cycle of discovering, culling, connecting, and re-classifying ideas and contributions. And this activity of understanding is also one of composing an artifact: a document – a structured collection – of personally-relevant citations.

The goal of this work is to facilitate the indivisible activities of composing, managing, and exploring personal digital libraries – and therefore, we claim, the understanding of them – by supporting reflection and arrangement of document collections in a multi-scale visual workspace.

RELATED WORK
Many elements of this project have already been investigated in work from several domains. Self-organizing document maps [6, 2] have been used to depict spatially the structure of a document collection’s topic-space – but while such maps afford some reflection, they are not designed to accommodate manual interaction and refinement of the collection.

Various image-based workspaces have let users spatially organize collections of web bookmarks [11] or digital photos [12], or facilitate image browsing with automated layout [3, 10, 5]. We too have studied users exploring collections of digital images (Figure 1) using Dynapad, the latest instance in the Pad++ lineage of zoomable interfaces [4]. Our subjects made use of specialized regional tools in Dynapad to help them organize their photos – for example, “timeline lenses” let them temporarily see photos sorted and grouped by their date, without permanently disrupting manual arrangements that were meaningful in other ways.

Figure 1: Organizing a photo collection in Dynapad

Other work has investigated people’s use of spatial arrangements in numerous cognitive tasks [7]. “Piles,” in particular, are extremely effective and convenient organizing structures, and there have been attempts to support their use in virtual environments [8]. We expect piles to serve as the dominant organizing strategy in our document-management workspace. Furthermore, we plan to adapt our existing regional tools to implement “Pile Tools” which can actively aid the user in sorting and arranging document piles.

PROPOSED WORKSPACE
The basic properties of the workspace we are developing are illustrated in the following sample scenario. Imagine that a user, who has already begun accumulating and arranging a collection of documents, finds a new PDF document on the web and wants to include it in her collection. She simply downloads it to any of several specially-monitored directories, where it automatically triggers three processes (Figure 2):

1. A parser extracts usable metadata fields and components, such as the title, author, keywords, citations, and any images within the document.
2. Using those components, an iconizer produces a compact “portrait”, a collage of text and images which serves as an enriched thumbnail [15]. Sample document portraits are shown in Figure 3.
3. Additionally, a profiler summarizes the document in an N-dimensional profile which is compared to profiles maintained for each pile in the workspace (and updated when documents enter or leave those piles). Any pile whose profile is “close enough” (i.e. greater than some threshold) to the document receives a copy of its portrait—that is, the new document is adopted into the collection by the most relevant piles.

![Figure 2: Adopting a new document](image)

Newly-arrived documents are highlighted so as to be easily spotted, since it is expected that the user will often wish to override the suggested placements. At any time, the user may move and copy documents and join or split piles to reflect her ever-changing judgments of the categories and relations between documents.

![Figure 3: Multiscale views of document portraits](image)

Since a document may belong to multiple piles, the user may find “brushing” useful: when one copy of a document is selected, all other copies in other piles are also highlighted.

In addition to viewing the document’s portrait at multiple scales, the user can click on a portrait to open a PDF viewer onto the document itself.

**Visual Geography and Lens Tools**

An important strength of an image-based spatial workspace is that it affords a visual “geography” [1]: the distinctive pattern of pile shapes and locations (as in Figure 3) can serve as a natural reference frame for the user’s memory of items and interactions. The visual geography of a collection need not be merely the aggregate of individual portraits; it may also include “semantically zoomed” [4] abstractions of piles—for example, replacing a zoomed-out pile with a label and a single enlarged, representative portrait.

Because both literal and symbolic landmarks form a spatial and historical reference frame, it is a priority that the visual geography remain stable over time. Although the user is free to drastically rearrange piles and documents at any time, because those changes are part of the user’s direct experience, we expect that they will not be as disruptive as automated rearrangement. Therefore, while the system does initiate some changes to the workspace layout (for example, when importing new documents, or automatically adjusting piles to prevent occlusion), we will deliberately limit potentially disruptive automation.

For example, we will restrict our regional tools to “lenses” which project copies of objects under them into various arrangements without disturbing the originals. In particular, since sorting by time can be especially effective in image-browsing [5], we expect to include “time lenses” like the examples in Figure 4.

![Figure 4: Examples of time-line and time-grid lenses](image)

A timeline lens, on the left, arranges the targeted portraits by the date of their acquisition—in the depicted selection, most documents were acquired at the same time (the pack on the left), but two (on the right) were acquired more recently. On the right, a similar lens arranges its own contents in a grid, sorted by acquisition date. Many other arrangements are also possible, by publication date, author, title, and other metadata parameters. Both lenses are semi-transparent, and the original portrait configurations can be seen underneath, undisturbed. When the lenses are resized or moved, the same configuration will be visible as before, serving as a stable reference landmark.

**EVALUATION and ITERATIVE DESIGN**

One product of this research is technical: we hope to develop Dynapad into an effective application for managing documents and other collections. To this end, we are conducting three phases of ethnographic observations as part of an iterative design cycle. We will continue development throughout each phase, to further inform and refine the details of our proposed design.

But equally important, we expect to apply our observations toward a theoretical understanding of three related phenomena:
1. How long-term interaction with a document collection is coupled to the development of one’s understanding of that domain;
2. How managing and exploring a document collection are closely interdependent aspects of the same activity;
3. How the multiscale, spatial, and visual properties of the workspace and its regional tools impact these behaviors.

**Off-Line Data Collection**

A crucial aspect of this research is the role of time: the development of a collection, and the user’s exploration of a domain, happens only gradually, potentially on a scale of weeks, months, or longer. Furthermore, we wish to preserve the authenticity of the user’s concernful activity, and not to induce artificial behaviors by forcing subjects to use the system only when they enter our laboratory. For these reasons, the primary source of data on users’ activity will be collected “off-line” — the system will be installed on the participants’ personal or office computers, so that they may work in their own space at whatever time and frequency they choose.

All user-initiated operations in the workspace—such as importing, copying, or deleting documents, and rearranging icons and piles—are logged and time-stamped so that all activity can be reconstructed and played back as a recording, in real-time or at higher speeds. Furthermore, the users themselves will have access to these recordings, and may find it helpful to replay past activity to recover forgotten items or to re-contextualize prior workspace states.

**Observed Sessions**

To complement the off-line logging of activity, participants will be brought into the laboratory for at least two different observation sessions, conducted in much the same manner as our earlier studies of photo-collection management: they will interact with their personal workspace projected onto a table and be videotaped while speaking aloud to an observer. In our experience, this tabletop setting elicits gestures which help to reveal the user’s cognitive model and augment the otherwise verbal-only protocol analysis. Additionally, we will use an “auto-confrontation” methodology, in which participants are shown a replay of some segments of their earlier off-line activity and comment retroactively on their behavior.

In summary, we expect this iterative cycle of ethnography and software development both to facilitate and to illuminate people’s use of personal collections of many types of digital information.

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**REFERENCES**