# Computationally-Enriched 'Piles' for Managing Digital Photo Collections

Dan Bauer, Pierre Fastrez, and Jim Hollan
Distributed Cognition and Human Computer Interaction Lab
Department of Cognitive Science, University of California, San Diego
Web: *http://hci.ucsd.edu* Email: {*dsbauer, fastrez, hollan*}*@hci.ucsd.edu*

## Abstract

*We explore and extend the metaphor of "piles" to include computationally-enriched piles, portable regions of automation in Dynapad, a multiscale workspace. We describe these collection-management tools and how their design was informed by observing people organizing collections of personal digital photographs.*

## 1. Exploratory Observation of Image-Sorting

People make extensive use of spatial arrangements – and especially piles – when constructing meaning [4, 7] and managing collections of paper documents [5, 9, 10]. Likewise, the utility of image-sorting workspaces has drawn increasing interest [8, 3, 1]. We continue these themes with Dynapad, the latest instance in the Pad++ lineage of zoomable workspaces [2]. Dynapad lets users explore and organize collections of digital photos and other media, using "computationally-enriched piles", portable areas of customizable automation, to create and manage diverse, changing, and opportunistic arrangements.

We interweave our development of Dynapad with "exploratory observations" [5] of subjects using Dynapad to organize collections of their own images. Our observations are not an exhaustive ethnography of photo-sorting, but they have helped us to identify some of the cognitive phenomena involved in using piles and developing meaningful spatial structures while exploring an image collection.

In addition to informal observations [11] of people's normal practices managing photo collections in their homes, we recorded video and audio data of six adult users (2 male and 4 female) organizing their photographs in Dynapad, our multiscale workspace. Subjects worked with sets of their own images (ranging in size from 114 to 293), which they organized to prepare for a subsequent task, negotiated individually, such as composing a web page or scrapbook, or browsing pictures for pleasure with friends or relatives.

A Dynapad workspace was projected onto a tabletop with a ceiling-mounted video projector. The sessions were recorded using both a ceiling-mounted camera, giving a survey view of the workspace, and a camera facing the subject, capturing interactions between her and the operator (see below) as well as gestures produced over the workspace.

We used a modified "Wizard of Oz" technique: rather than operating the interface themselves, subjects were assisted by an operator sitting next to them at the table. Subjects expressed their intentions by speaking and gesturing freely at the workspace, without having to learn or being constrained by Dynapad's controls. This collaborative arrangement turned the interaction with the workspace into a conversation with the operator, providing us with a running commentary on the subjects' motives and intents throughout their activity.

## 2. Cognitive Aspects of Piles

Numerous empirical studies have demonstrated the ubiquity of piles in people's management of paper document collections. This includes early work by Malone [5] on how people organize their physical desktops, in which he contrasted strategies of "filing" and "piling". Similar results can be found in Sellen and Harper's recent comprehensive documentation [9] that the paperless office is no nearer now than it was 30 years ago. In their examination of the management of paper archives, Whittaker and Hirschberg [10] highlight cost-benefit tradeoffs involved with the strategies of filing and piling. For example, while filing provides a formal structure to paper documents, it is difficult to generate appropriate labels and use them consistently. In constrast, pilers "experienced fewer overheads in managing their data and found it easier to clean up their archives" [10, p. 165].

Given the apparent usefulness of piles, their advantages as reminders, and their lesser attentional demands, it is surprising that they have not been more extensively applied to managing digital information. While Mander, Solomon, and Wong [6] proposed a pile metaphor for supporting casual organization of information over a decade ago, there have been few implementations of piles to support management of personal information collections.

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One goal of our work is to implement the affordances of physical piles in a digital workspace. Let's consider briefly some aspects of a typical physical pile, a stack of papers:

- *Substructure.* Unlike a jumbled "bag" or "set", a pile is not homogeneous; its members have relative positions which can encode information. The simplest stack has one ordinal dimension, but more complex structures are possible by marking "subpiles" with physical delimiters (e.g. folders) or by offsetting or rotating them.
- *Cohesion.* Pile elements can be moved together and substructure preserved with little effort. Even "loose" piles can become cohesive if placed on a moveable "palette", as detailed below.
- *Contiguity.* Elements are co-located such that attention may be iterated over them without effort or interruption.
- *Occlusion.* Items cannot all be seen at once nor manipulated with equal ease; they have a *differential access cost*. Most obviously, occlusion trades equal visibility for conserved space, but that tradeoff has a more subtle cognitive cost: it does not merely hinder access to known targets, but also limits the capacity for unanticipated objects to *remind* us of their presence. This function of reminding has been shown to be an important consideration in managing paper archives [10, 5].
- *Aggregation.* A pile as a whole has potentially informative features beyond those of its parts. For example, a "tall" pile implies many members; a pile with unaligned or "ragged" edges suggests frequent usage (or manual assembly, as in [6]). These aggregate properties can be used as recall cues when looking for a known pile or opportunistically serve as reminders of existing piles.

## 3. Dynapad's "Open" Piles

The term "pile", taken literally, implies all of the features above, and the piles proposed by Mander et al. [6] afford some variant of each. But we can extend the metaphor to new designs, and re-engineer its cognitive affordances by deliberately abandoning some of these constraints. In particular, Dynapad's "open" piles relax occlusion.

We have explored many variants of the "open pile" metaphor, which we cannot discuss here in limited space. For the concerns of this paper, we will focus on two variants: the "clump" and the "tray".

A *clump* (Figure 1, top) is the most literal interpretation of the classic pile: objects that are placed within the clump's boundary stick together, maintaining their relative positions. A clump automatically adjusts its boundaries when items are added or removed. Items may be gripped and moved individually, and the clump may be moved as a whole by gripping its "body" (i.e, any location in the background of a pile). In addition, when zoomed out these

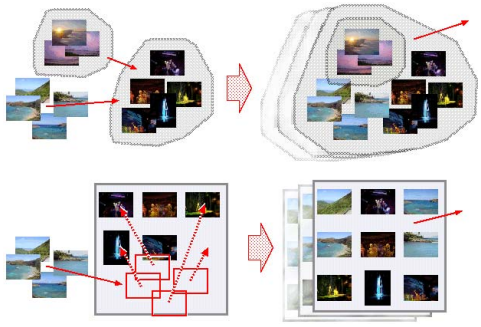

**Figure 1. Dynapad's self-adjusting clump (top) and grid-layout tray (bottom).**

clumps "fuse" together: dragging any member will move the entire clump, preventing accidental disruption of its structure at small scales. Finally, clumps may be nested to arbitrary depths.

Clearly, clumps share most of the properties of classic piles: substructure, cohesion, contiguity, and aggregation. We emphasize however that *occlusion* is optional; indeed, as we explain below, many cognitive benefits follow from de-occluded piles.

*Trays* (Figure 1, bottom) are similar to clumps but offer *automated substructure*: items in a tray are automatically sorted by some metadata value[1] and arranged in either a grid or timeline. As a consequence, trays always de-occlude items and override any manual arrangements of their contents.[2] In addition, trays currently do not permit nesting (since it is unclear how subtrays should be included in an arrangement of date-sorted images). In short, trays are less flexible and expressive than clumps but also require less effort to manage.

Because the design and development of these tools occurred in parallel with our observations, the first half of our participants worked essentially with no pile-tools, and the later half had only trays available (clumps, although simpler than trays, were actually developed later). Even without explicit clump-tools, all participants maintained implicit open piles by spatially grouping images and moved them as a unit (selecting and moving all members at once).

## 4. Cognitive Consequences of Open Piles

Open piles, both the implicit groupings and the explicit trays and clumps, offer both costs and benefits by giving up occlusion. As expected, the most obvious cost is that they require more space. However, this is mitigated by Dynapad's zooming capacity; space is essentially unlimited.

[1] In this study, we sort photos according to the date they were taken, as determined by the *exif* header embedded in the image data by the camera.

[2] Future versions will permit manual adjustment of the automatic arrangements.

Another cost is that piles lose some capacity for directing attention to important items. However, the more-visible substructure can carry some of that role – for example, serial scanning is facilitated by trays' tidy rows. But overall, open piles offer the user more control: occluding some items, enlarging some, and using substructure in flexible ways to facilitate their own access and attention.

In exchange for these costs, open piles offer many benefits. Unlike Apple's piles [6], they require no special "browsing" action; the cost of accessing items is uniformly low. Consequently they afford many forms of *reminding*.

- *Reminding by Instances.* Subjects were reminded of organizational goals when unlooked-for pictures happened to catch their eye. For example, subject YF runs across forgotten pictures several times, while attending to either the same category (e.g. "water pictures") or an unrelated category, and often pauses sorting that category to take care of the forgotten picture.
- *Reminding by Context.* Individual photos may be more discernible in a visible context of other photos. Two subjects, YF and JL, use a timeline tray to store the pictures that remain once they are done creating piles. They both argue that each of these 'random pictures' would not make sense in isolation. But the tray situates each photo chronologically relative to the others and creates a context to remind them what each photo depicts.
- *Reminding by Structure.* Information invested in the pile substructure can serve as a reminder. For example, subject DN's final workspace includes multiple levels of organization, each with its own arrangement principles. A chronological area groups event-specific piles as a timeline. One pile is cluster of three subpiles: two panoramas and a series of landscapes organized according to location, color and saturation. This "volcano-landscape" subpile is even shaped like a mountain (according to DN) with pictures of the volcano's summit at the top and pictures of its foot at the bottom. All of this informative substructure reminds DN what the pile is about and where to find specific pictures.

In summary, we see that the full visibility of open piles enables many instances of *reminding*, resulting in opportunistic strategies essential to the development of meaning.

## 5. Conclusions

In this paper, we examine the usefulness of piles for managing digital photo collections, characterize general cognitive affordances of piles (i.e., substructure, cohesion, contiguity, occlusion, and aggregation), and summarize observations of people organizing collections of their personal digital photos. Our focus throughout has been on the cognitive consequences of piles and how they can serve as guides for design. This led to a Dynapad implementation of two variants of piles: clumps and trays. These "open" piles are relatively simple examples of how an otherwise inert visual workspace can be enriched with local computational support. More abstract variants of the pile metaphor can incorporate additional refinements of the cognitive affordances listed above. In particular, they can provide additional support for piles' *substructure*, other arrangement formats. We continue to explore these variants in current work.

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