

Pixaura: Bridging the Gap Between Selecting and Sharing Digital Photos

ABSTRACT

Current advances in digital technology promote capturing and storing more digital photos than ever. While photo collections are growing in size, the amount of time that can be devoted to viewing, managing, and sharing digital photos remains constant. Photo decision-making and selection has been identified as key to addressing this concern.

After conducting exploratory research on photo decision making including a wide-scale survey of user behaviors, detailed contextual inquiries, and longer term diary studies, the Pixaura system was designed to address problems that emerged from our research. Specifically, Pixaura bridges the gaps between importing source photos and sharing them with others. To create the experience desired by novices and hobbyists, the system must incorporate certain core elements: 1) ease of use, 2) flexibility to experiment with connections between selected photos and groups, 3) control of access to shared photos, and 4) a tight connection between selecting photos and sharing.

Author Keywords

Digital Photos, Selection, Phototriage, Sharing.

ACM Classification Keywords

H.5.2 User Interfaces, User-centered design, Graphical user interfaces (GUI)

INTRODUCTION

The advent of digital photography has made capturing photographs easier and less expensive. This has led to an explosion in the number of imported and shared photos that people acquire on their computers. While the capabilities of technology are also increasing at a phenomenal rate, human

capabilities are not. The amount of time and attention that can be devoted to photo collections is relatively fixed, if not shrinking due to competing demands for users' attention. As Kirk and Sellen point out [6] the entire process of working with digital photos which they call *photowork* has received surprisingly little study. While there has been a great deal of study on digital image display, searching, browsing, and other aspects of digital photo management, other parts of photowork (or as we call it, the *digital photo lifecycle*) have received less attention.

We define the *digital photo lifecycle* (see Figure 1) as consisting primarily of three key stages: selection, authoring, and viewing. This cycle is mainly fueled by the desire to share photos [14] and the stories connected to them with others [4]. The selection process, which we refer to as *photo triage*, involves making decisions about individual photos, ranking photos, as well as sorting photos into groups. Authoring can encompass actions such as annotation or labeling these photos, or the creation of experiences from photos. Viewing can be performed by the author alone, jointly along with an audience, or by an audience independent from the author. Of these stages, the overarching task of selection demands a delicate balance between decisions influenced by the storytelling quality of photos, the method of sharing, and the social relationship with the audience.

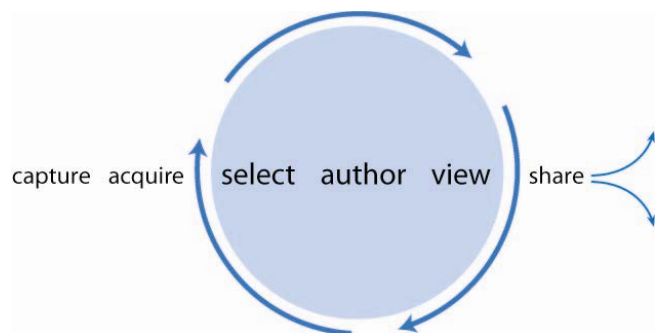


Figure 1. Digital photo lifecycle.

Through exploratory research, iterative ideation and evaluation, we have identified that people often find it difficult to find photos to share and have developed a system called Pixaura to bridge the gap between selecting

and sharing digital photos. The Pixaura system has been designed to provide a space in which people can leverage the freedom and familiarity of physical photo interactions along with the power and flexibility of the digital realm. This system addresses the motivational user needs of social connectivity and privacy, as well as other design implications gathered from our exploratory research. Pixaura is a desktop-based photo triage application that integrates into existing photo management and sharing systems, targeted at novice and photo hobbyists.

RELATED WORK

While our focus is on users working with a subset of their photos primarily for the purpose of photo triage, it is important to note that considerable work has been done in the digital photo domain. We break this research up into areas devoted to management, visualization, authoring, sharing, interaction, and selection.

Photo Management

Organization has been primarily focused on systems for applying tags or searching based on tags [22, 3, 8, 15]. Tags and other annotations create additional metadata to retrieve photos and create connections between them. Successful retrieval relies largely on people manually attaching appropriate annotations to each photo, since automated image content analysis is still limited [22]. While photo triage can be viewed in part as a form of tagging, our work focuses more on selecting an individual photo or group of photos for sharing or authoring. This is in part because studies have shown that photo annotation mainly occurs for sharing purposes, and not for organizational purposes [14]. Other studies [3] show that consumers typically put little effort into annotating their photo collections, which can be seen as work. Recent internet-based experiences such as Flickr have created more compelling reasons for annotation of individual photos since they bring annotation and sharing closer together. They also allow the task of photo annotation to be distributed to friends and potentially the entire Flickr community, however they can sometimes be seen as shifting the burden of photo triage from the author to the viewer (when the author just uploads all photos taken from an experience at once).

Other systems [6] use social activity and cell phone cameras to help annotate pictures based on the activities of a few dedicated users. While this somewhat ameliorates the work involved, significant effort can still be involved in picking a select few pictures to print or share with others.

Semi-automatic approaches for facilitating quick and easy labeling of photos containing people using face detection technology has also been tried, but most face detection or recognition technology still show some limitations in their complete functionality [9, 24].

Visualization of Photos

There has also been a great deal of work regarding how to visualize large collections of photos. Metadata is often used

to layout a collection for easy retrieval of individual and groups of photos based on attributes such as date, event, people, and places [5, 12, 13]. The FotoFile system suggests an opportunity for using metadata from photos that are organized as stories [15].

A frequently identified visualization technique in many systems is automatic grouping or clustering of photos to improve user's access to them. Some of the automatic capabilities include semantic grouping, time-based grouping, and color-coding [12, 17]. In commercial products such as Adobe Lightroom, Picasa, and Apple iPhoto, users can choose to view selected groups of photos by different criteria, which in most cases was by date and event. However, some automatic grouping of photos showed problems in that they can compete with user's manual organization method, which delay the process of selecting or finding specific photos [12]. In the Pixaura system, we have chosen to group photos based on time since that often corresponds to user notions of events. This in turn helps people rapidly move through many collections of events.

Other systems create automatic collages given a set of pre-selected photographs, but leave the choice of photographs to end users [20].

Displaying photos in thumbnails has proven to be efficient for users as they facilitate visual search and almost all prototypes or products implement this view in their system. The Digital Shoebox automatically sorts an entire collection of photos in chronological order and displays them as thumbnails [19]. Similarly, the Time Quilt system uses representative thumbnails in a timeline view [12]. Recent commercial products, both web services and desktop applications, are also based on thumbnail displays, including Microsoft Windows Explorer, Picasa, and Flickr.

Authoring

The authoring of photo based experiences occurs at both a per picture level when editing [Photoshop, Elements, Group Shot, etc], and at the group level when storytelling [4, 21]. For each of these tasks, appropriate tools for selecting photos are fundamental, and have largely been left to whatever tools are available in the host operating system.

Sharing

The most common mediums through which people share their photos include e-mail, online albums, personal websites/blogs and even sharing in person. The motivations for sharing photos are manifold: people share experiences, create awareness, augment communication with visual elements, enhance their social presence, and deepen personal and community relationships [7]. The social aspects, such as the memories and conversation, are of primary importance in photo sharing [18].

Sharing photos in person was described as the most common and enjoyable activity and it is seen as a way of re-creating the past and reliving the experience with others who were there at the time. Prototypes like PhotoArcs [2] lets users add narratives to online photo collection in a way that mimics the face-to-face sharing patterns. However these prototypes do not explore how to select the photos to share.

Photo Interaction

Many systems draw upon physical world analogies to design new interactions with digital documents. These physical analogies are successful with small sets of photos, but tend to have breakdowns when dealing with large collections. One such system is BumpTop [1] in which a user interacts with files in a virtual three-dimensional space using pen input. We draw heavily from the BumpTop work in the design of the Pixaura system, but tailor the interaction for the more specific task of photo selection and sharing. The drag-and-drop interaction mechanism is natural for photos as it maps to how people hold and move physical photos. This technique was used in prototypes for actions such as photo labeling [13, 15]. This type of interaction is an intuitive interaction for novice users.

The need for both an overview with thumbnail sized photos and full sized photos for details makes it important to be able to switch rapidly between the two. To achieve quick switches in photo collections Zoomable User Interfaces (ZUIs) allow users to zoom in and out across spatially distributed photos [5, 12]. These systems often focus on using these techniques for large scale photo management, but the same techniques can be adapted for photo selection as well.

Photo Selection

Finally, others have observed the need for work in the photo selection space. Platt et al [17] observed that a common behavior referred to as the funnel effect shows that there are multiple granularities at which people select photos. While people capture many photos, they save a subset of them on their computers. Of these saved photos, they share only selected groups, and print out even smaller subsets. Studies found that selection criteria included good image quality, good composition, and more personal preferences. Selecting and sorting were the most common and time-consuming activities observed among people who participated in the research studies [14].

Current systems support absolute inclusion or exclusion from a set. There is no fuzzy ground to make conditional decisions, or to indicate that one photo belongs more to a group than another photo. Many people in our user studies desired features along these lines and hence this was incorporated into the Pixaura system.

EXPLORATORY RESEARCH

In order to gain a better understanding of how people select photos for sharing, we conducted a broad web-based survey

with over three hundred participants, eight contextual inquiries, four diary studies, and elicited retrospective accounts from ten users. Our focus of these studies was to explore photo selection that takes place in preparation for sharing stories, and how social factors motivate and influence this process.

Survey

In order to confirm preliminary qualitative findings across a larger, more diverse set of people and find new trends in practices, we conducted a survey on the web. The survey was disseminated to a diverse group of people from April 18th to June 26th, 2007. We had 420 individuals respond to the survey, with 300+ participants responding to all questions.

Age Group	Percentage of Participants
18 – 25 years	38%
26 – 30 years	22%
31 – 40 years	24%
41 – 50 years	12%
50+ years	4%

Table 1. Survey Participants

Questions

The questions in the survey were objective questions that asked participants about their digital photo usage. Information about the type of software used, as well as the frequency of activities and common user behaviors during importing, organizing, selecting, and sharing photos was collected.

Survey Insights

Sharing quantity

When asked about how frequently photo sharers chose different quantities of photos to share, we found an overwhelming number shared only selected photos (see figure 2). 53.5% of the respondents share only selected photos frequently and 63.5% never share their entire photo collection. This confirms that the photo triage process is common in our target user base.

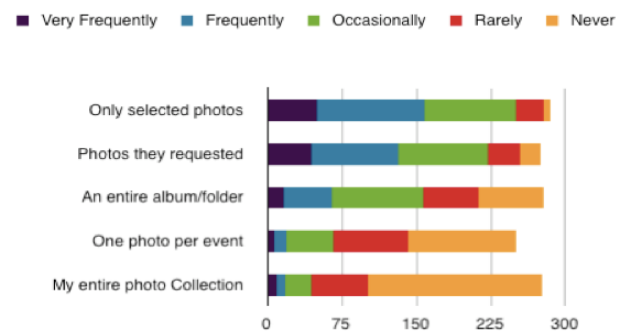


Figure 2: How many photos do you usually share with others?

Sharing Methods

We found that e-mail was the most common method used for sharing photos among our respondents. Sharing in person in front of a common desktop or laptop was also widespread. The web based mediums most frequently used for sharing photos included sharing them through online photo albums, blogs, and social networking websites.

We have identified a range of mediums that users need to be supported and indeed confirmed behaviors indicated by our contextual inquiry, which is that 1) people were sharing small, tailored groups of their photos, and 2) people used e-mail as a secure medium for sharing photos online.

Moreover, that more focused channels for sharing, like e-mail and sharing face-to-face, are the most prevalent mediums may perhaps indicate two things that we also found in our contextual inquiry: 1) people are sharing tailored groupings of these photos, and 2) people find e-mail to be a secure medium of sharing photos online.

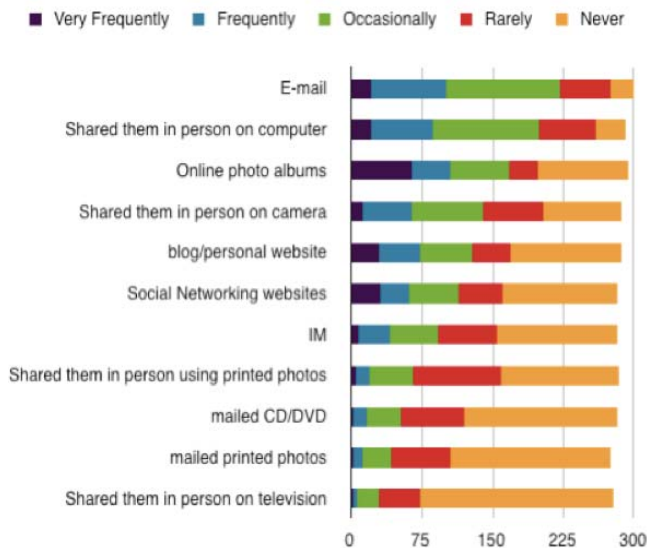


Figure 3: How did you share your photos with others?

Organization Methods

Participants also reported that when they organized and sorted their photos, that they predominantly grouped them by event and by date (see figure 4). They also reported that renaming photo files was not a widespread method for handling them.

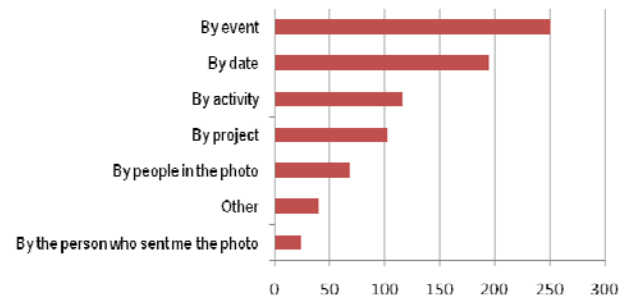


Figure 4: How do you organize your photos?

Contextual Inquiry and Retrospective Accounts

In order to examine some of the trends that emerged from the survey, contextual inquiries were conducted with eight participants. They were performed while the participants interacted with their personal photo collections, either at their homes or at their work-places. The insights from each interview were modeled individually, and later consolidated into flow and cultural models. The insights from the more informal retrospective accounts were also incorporated into the consolidated models.

Participants

While any digital photo taker was a potential participant, we initially targeted relatively novice users who had a large influx of new photos, such as a married couple with a new baby or people returning from a vacation trip. Of our eight contextual inquiry participants, six were in the age group of 24-55 years. The remaining two participants were retired and were aged between 60 and 65 years. The participants for our retrospective accounts varied from college students to business consultants.

Contextual Inquiry Tasks

We observed participants performing photo selection during photo import from a camera, or when receiving photos. Further photo selection tasks included organization of photos on the computer, filtering out unwanted photos, and most importantly for our purposes, preparation for sharing photos. The mediums for sharing that we observed included email, personal blogs, photo sharing websites such as Flickr and Yahoo! Photos, as well as social networking websites such as Facebook and Cyworld. During the inquiries, the participants were probed and questioned about their actions and behaviors as they went about performing their tasks.

Insights from Contextual Inquiry and Retrospective Account

Privacy

Privacy grew over time as an important concern for our participants. After being spammed with emails about their public online albums, a wife and husband added passwords to restrict who is allowed to view their photos. When selecting a photo sharing site, they evaluated the privacy controls, and specifically mentioned that they found it difficult to configure permissions on Flickr. As a result, this privacy issue restricted most of our participants from

sharing photos online, and hence caused them to use e-mail as a medium to share their photos.

View Switching

Our observations confirmed the postulated user need for switching between viewing their images full-sized and seeing them as thumbnails. Participants sometimes flipped through full-sized images like a slide show to compare similar images very effectively. Some users were able to organize their photos and make decisions based on only the thumbnail view.

Subjective Decision Criteria

None of our participants could quite explain to us how they made certain decisions about their photos. Many participants used the term “best” when selecting photos, and mentioned photo quality, how interesting it was, how good the people in it looked, or rarity of that kind of photo when asked to explain what “best” means. From our observations, photo selection relies heavily on emotional connections to photos hence we doubt that this photo selection process can be completely automated. There have been some attempts to do so at least partially. Horvitz et al worked on a system that attempts to generalize using Bayesian learning trained on a few collections [11]. While the system was able to use features like the presence of faces, lack of blurriness, lighting, and some notion of event clustering, semantic features were not available from the pictures themselves.

Recording Decisions

There is a distinct lack of support for recording users’ thoughts about photos during the photo selection process. We observed the use of external tools, such as text editors, to write notes about which photos they have selected, as well as participants keeping track of their decisions in their mind. Users did not want to move pictures from their original location since they would lose context. When copying pictures to a new location, all relation to the original image was lost.

Multiple Photos and Passes

Most of our users took multiple photos of the same subject, and later chose the best shot on the computer. One user said “I keep taking pictures until I get a good one.” The rejected photos either remain mixed in with the album if there is no storage space constraint, or are cleared from the temporary workspace a user is utilizing, such as the desktop. The funnel effect [14] and multiple passes (meaning that a user would go through a collection several times) while selecting photos were also observed.

Diary Study

To further understand peoples’ practices and behaviors over time, we conducted a diary study with seven participants and out of which four participants responded to most of our questions. The diaries consisted of questions about their behaviors at every point in the digital photo lifecycle. These

questions were to be answered whenever the participants dealt with digital photographs.

Participants

Diary studies required reliable participants who were both active in the target activity as well as flexible enough to invest time in recording related details. Four participants returned completed diaries. The participants consisted of a college student, a married couple, a homemaker who home-schooled her children, and a professional, whose ages ranged from 22 to 60.

Diary Study Insights

Duration of activities

Most sessions of activity that involved working with digital photos lasted less than half an hour. Participants recorded various activities including acquiring, editing, organizing and sharing digital photos. Upon reflection on her use of time, one of our participants wrote that she had yet to learn efficient practices to edit, manage, and share her photos, offering, “I’m still floundering around.” Mostly this was because, as she said; “I feel rushed much of the time and haven’t studied the programs that I am using even now.” Yet she also wrote that she wanted to “spend more time with [her] pictures.” Other participants similarly identified that they wanted to spend less time mediating interactions with their photos through tools and more time directly with the photos. Others reflected on challenges with their photowork that extended the time needed to address their photos. Another participant wrote that she “I would like to get them more organized but organization costs time.” However, another participant—her husband—found the cost of disorganization. He spent extra time compressing photos for email, which he had already done before, because he had lost track of these.

Interval between activities

Analysis of the diary study also involved examining the intervals between sessions, in order to measure the frequency of activities involving digital photos. Some participants were able to identify factors that influenced this frequency. One of our participants related that she would share more often if she were able to easily provide contextual information about the photos. Right now she primarily shares with her immediate family who uses them to supplement their other encounters. She wrote “I don’t share many photos – except with my immediate family. I would probably send out more on a regular basis if it were easier to label and organize them.”

INSIGHTS AND IMPLICATIONS

Our tool for selecting photos in preparation for sharing, Pixaura, embodies the design implications of seven key findings resulting from our exploratory research, and refined during our ideation and evaluation phases.

Motivational Implications

1. Social Connectivity

People share photos mainly to socially connect with others.

The motivation for sharing photos is often to strengthen social relationships. Since this is the case, our design seeks to explicitly make it easier to share photos rather than a separate process for annotating and organizing them. We do this by incorporating sharing tools directly into same space used for organizing the photos.

2. Privacy

People have great concerns for privacy of photos and personal information.

Since private photos and personal information are separate from shared and public spaces, users trust that a stand-alone system can be more effective in preserving their privacy than web based albums. By creating a desktop application, instead of an internet based application, the distance between private and shared is established by the digital boundary between personal computers and the internet. To maintain the social connectivity through internet sharing, the desktop application acts as a portal to the web, where users can protect their personal information, and review their sharing history to various digital outlets.

Strategic Implications

3. Switching Views

People constantly switch between thumbnails and detailed photos to make photo triage decisions.

Selecting photos to share occurs both when viewing photos in detail and in an overview of many photos, so it is important to maintain the ability to make decisions in all views. This is in addition to supporting specific, size appropriate actions such as photo retouching. Because of the frequent switching between views, it is important to provide clear, smooth transitions to maintain context of where the photos currently belong.

4. Multiple Photo triage Passes

People make multiple selection passes on the same photo collection.

As users refine their photo selections, potentially for multiple audiences, they need to be able to express different levels and types of decisions. The flexibility to make decisions on individual as well as groups of photos, and then review these decisions in context of the set of photos, supports the multiple passes users make as they photo triage. Especially as version management issues arise, it is important to be able to return to previously created versions of a group of photos.

Other Implications

5. Dynamic Tasks

People set new goals and multi-task during short, intermittent photo interaction sessions.

By allowing photo triage, viewing, and sharing photos to occur in a single space, users can attend to multiple tasks without having to switch application contexts. New goals that arise while pursuing an initial goal, such as finding a photo to email to Mom while selecting photos to add to a web-album shared with friends, can both be addressed within the same space. Users have the freedom and support for executing different goals as they interact with their photo collection, while maintaining the ability to return to their original task and context.

6. Flexibility

People benefit from sufficient balance between structure and flexibility in organizing their photo collection.

With a loose structure and utilization of spatial relationships, users have the ability to create connections between photos or group of photos, without having to be explicit about them such as placing them in files or even albums. Here, the freedom and flexibility of physical photo sorting is merged with the advantages of digital space, such as copying photos and space manipulation.

7. Leisure

People perceive photo triage as a lot of work.

To prevent interactions that feel like mundane and tedious work, our design strives to be fun and makes progress easily visible. The playful visual language and communicative animations were designed to eliminate the rigid nature of current photo applications and to create an engaging experience for our users.

PIXAURA

The three main components of our solution are the album dock, the photo piles with auras, and the share tool bar. The album dock is where the source photos from a selected folder are held accessible for use. The main manipulation in Pixaura centers on creating and altering the placement of photos from the album dock into various photo piles and their associated auras. These piles are then shared directly with friends and family using the share toolbar.

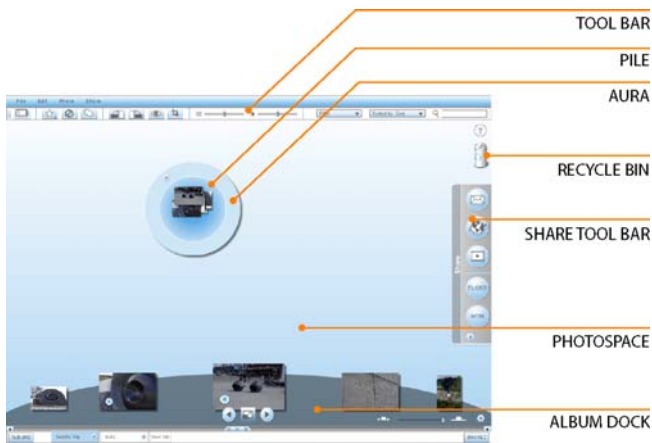


Figure 5. Pixaura Terms

Photo Piles with Auras

Dragging a photo from the album dock to the main space, referred to as the photospace, creates a new photo pile. The pile is given structure with a two-tiered circle, centered around the given photo. The circle was chosen over a rectangular structure because of the playful and organic feel it created, although the tradeoff is in the amount of unused space that is created by the rectangular photos. Some study participants also told us that placing rectangular photos in round piles felt unnatural to them. More photos can be placed in the center of the pile, or they can be placed in the outer-tier, known as the aura of the pile.



Figure 6. Multiple Piles and Album Dock

The aura allows for users to associate photos with a pile, without having to add them to the pile itself. This supports users in making tentative decisions. When sharing piles, the photos in the aura are not shared, so only the photos the user has placed in the center of the pile are seen by others. In this way, the aura also allows for privacy and ranking of photos, as only the ones chosen as public or best of a group are shared. While a global star-based ranking system requires a user to decide what each level means for all instances, this local ranking can have different parameters for every pile. The two-tiered pile also allows users to share different selections of photos from the pile, while keeping the same group of photos together. We limited the pile to two tiers to explore how users interact with a structure that provides fuzzy associations. It is conceivable that more tiers

would provide users with more flexibility in expressing local ranking of photos; however, the optimal amount of tiers would need to be explored with further research.

The piles combine the flexibility found in physical photo interaction with the benefits of digital space; photos can be easily placed in multiple piles, something that would be difficult in a non-digital space. The piles themselves can also be moved in the photospace to create spatial relationships, or be minimized when not being used. Pile labels can be added and edited directly on the title bar of an opened pile, or at any time through the pile options menu. The combination of the pile layout and labels allow users to easily recall the previous work they have done.

Album Dock

When a photo is dragged from the album dock into piles, a linked copy of that photo is created in the photospace, and the photo in the dock is marked as being placed in a pile. The album is kept intact in order to preserve the original context from which the pile photos come from. The knowledge that their original folder or album of photos will not be altered gives users a sense of freedom to manipulate them within the piles in the photospace, knowing that they can always return to or refer to the original.

Retaining context is important in the album dock, which is why smooth transitions are used for scrolling through the photos as well as enlarging a thumbnail to view more details. Photos in the album can also be clustered together based on events and different versions of the same photo. So it always preserves the original photo. To provide a better overview, the number of photos displayed in the dock can be increased. A resulting trade off is that the decreased size of the thumbnails may make it difficult for users to recognize unfamiliar photos.

The photos in the album dock are shown in the order they were taken, as ordering by time is a natural and frequently used organization method we observed in our research. Also, photos in the album dock can be shown in stacks based on time-clustering or image-content clustering. The benefits of this are more natural context for each photo as well as easing the user to move between sets of related photos.

Refining Decisions

To assist users in refining selections, they can open a pile to look through and reorder the photos in a grid view. The grid has a fisheye nature to keep consistent with the curve of the pile and to provide detail where the user is looking closer. The photos can be moved between the center and aura of the pile, as well as to the other piles, minimized to the side of the photospace. Manipulations such as tagging and cropping can be made to individual or groups of photos. Users can also enlarge photos from both the center and aura to compare photos side-by-side, and switch back and forth between photos to make fine tuning decisions.

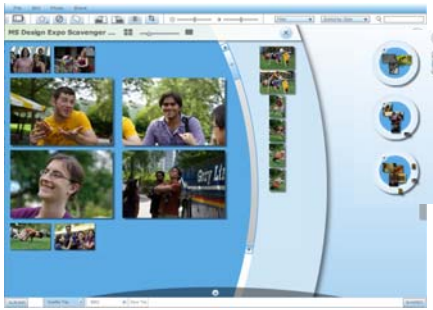


Figure 7. Open Pile with Minimized Piles

Sharing Piles of Photos

To share, users can drag a pile to a portal on the share tool bar. The standard portals consist of the most common digital photo sharing mediums; email, web, and a presentation mode for sharing in person. In addition, users can create custom portals to frequent recipients or websites, and edit them as social demands change. When sharing, a preview of the piles of photos to be shared is opened, where users can add additional notes depending on the sharing medium. Piles can be added to or removed from the preview so that multiple piles can be shared at once. These share portals bridge the gap between organizing and sharing photos, making it easy to stay socially connected through digital photos.

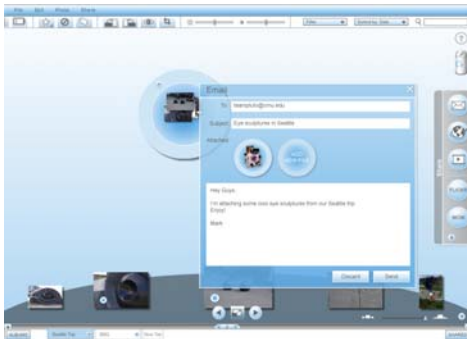


Figure 8. Sharing a Pile through E-mail

USER REACTION TO THE SYSTEM

While a formal study of Pixaura was beyond the scope of the current work, we did evaluate the system with a think aloud study. Participants were novice photographers, who were given one-time-use digital cameras to capture photos to use in the Pixaura system. The 10 participants, ages 23-60, carried out two sets of tasks with no prior training. The first set of tasks was meant to familiarize them with Pixaura and see how easily it can be picked up. After this set of tasks, any important aspects of Pixaura that the participant did not understand were explained to them. The second set of tasks consisted primarily of the participants using Pixaura to explore and share a set of their own digital photos for the first time.

Intuitive and Organic

When using Pixaura, participants found the drag-and-drop interface intuitive and welcoming. Confusion regarding the creation of piles in an early prototype was overcome by providing stronger visual feedback. The visual language, consisting of smooth curves and animated transitions, created an organic flow that users reflected upon after their experience with the system.

One participant commented that Pixaura will encourage people to take more photos. Seeing the already created piles would remind users of things to take photos of, which then they can add to previously created piles,

Understanding Piles and Auras

To test if participants would figure out the pile and aura structure on their own, we did not explain their purpose beforehand. Most participants did not pay attention to the aura until it was explained to them in between tasks. This is likely because the concept of a conditional decision in a digital space was unfamiliar to them.

While a few participants used the aura as it was designed for, others took advantage of its loosely defined purpose. One participant created a group of the best photos in a pile, and then placed all the photos of her cat in the aura, because “no one else wants to see photos of [her] cat.”

From our think-aloud studies, we saw that the piles tend to form either theme based groups, or recipient based groups. The amount of piles created during the tasks was small, with no more than four in the photospace at a time. To a degree, this small amount was caused by a constraint in the number of source photos the participants had. However, it is feasible that for a source album from a single event, a user will create a limited amount of piles based on theme and recipient.

CONCLUSION

The Pixaura system was designed based on a variety of user research to address dissatisfaction with the current photo lifecycle process.

By using a familiar, physical metaphor for moving photos around a physical space, novices were easily able to use the system. Allowing ‘fuzzy’ membership into groups through the ‘aura’ around a pile matched user requests to help deal with ambiguity. Animated transitions between modes and the ability to perform all tasks from every mode helped users both keep context as well as work at the appropriate level of detail. Tying selection and sharing closely together was key to helping users do this most commonly requested action with photos, while keeping the application primarily on the desk-top with a clear bridge to the internet addressed privacy concerns for users.

FUTURE DIRECTIONS

There are further insights from our research and design that were out of scope for the timeline of this project. We identified several areas in which Pixaura can be expanded

to better integrate into how users interact with their photos. These insights are also given as inspiration for future work on the digital photo lifecycle, and the photo selection process in particular.

Filtering and Sorting

When selecting photos from large albums, assisting users in finding photos through filtering and sorting becomes important. This need was noted in our contextual inquiries, where participants were able to express what they wanted to look at, but did not have the support to easily do so. Filtering and sorting narrows the visual search space to make triaging easier and faster for users. Achieving this in a meaningful and intuitive way that also promotes the leisure mentality of interacting with personal photos is challenging, but would provide a great benefit to users with large albums and collections.

Stacking

To manage multiple shots of the same subject, existing automatic algorithms such as face detection and time proximity can be used to cluster photos together into stacks, in addition to manual creation by users. Stacks are currently being utilized in professional photo management software, such as Aperture by Adobe, but have great potential for being used for more novice photo hobbyists. Stacking can also be utilized for version management; an edited photo can be connected to the original photo by stacking the newer version on top of the original and other edits. If the original photo is duplicated in another location, the newly edited versions can be stacked below the original to preserve the connectivity between the versions.

Connecting Photos

Creating connections, and revealing underlying connections, can help users navigate their photo collections. Using visualizations to show the different ways photos are related to each other can help users search for photos they are communicating stories about. Connections can have different weights, and result from photos being in the same album, being shared to the same person, or depicting the same location or individuals. Connecting groups of photos together can create meaningful associations that assist users in understanding their photo collection. In Pixaura, these group connections could be made by providing users the ability to partially combine piles, creating a link with their auras.

Automatic Annotation from Sharing

Many of our contextual inquiry and survey participants realized the benefits of annotating their photos, but indicated that it took too much time and effort. However, users did add information to photos when sharing, such as email text and renaming file names. Utilizing the information already generated when users share for automatic annotation creates the personalized annotations that users do not want to spend the time and effort on. The influences caused by the need for accuracy and privacy

make this annotation extraction a challenging area to explore within the digital photo lifecycle context.

Other Digital Photo Selection

When photo sharers do not take the time to triage their photos, but instead “dump” all of their photos into a shared repository, the audience is left with the burden of selecting the photos to find those that interest them. There is a great opportunity here to assist selectively viewing received photos, while addressing how this will influence social relationships between the sharer and the audience.

Other areas worthy of exploration are collaborative photo collections of spouses, as well as synchronous sharing sessions, such as in person and via instant messaging. While current photo applications are mostly designed for a single user, and hence can only be controlled by one person at a time, creating photo application for promoting social connectivity through collaborative photo selection seems opportunistic. We acknowledge that many researchers have explored collaborative interaction experiences for digital photos, and believe that such interests can be expanded to the selection process as well.

With Pixaura, we have explored only a portion of the digital photo lifecycle regarding how to support selecting digital photos for sharing. Many more opportunities for innovation exist in this area, which we encourage others to explore.

REFERENCES

1. Agarawala, A. and Balakrishnan, R. 2006. Keepin' it real: pushing the desktop metaphor with physics, piles and the pen. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Montréal, Québec, Canada, April 22 - 27, 2006). CHI '06. ACM Press, New York, NY, 1283-1292.
2. Ames, M. and Manguy, L. 2006. PhotoArcs: a tool for creating and sharing photo-narratives. In CHI '06 Extended Abstracts on Human Factors in Computing Systems (Montréal, Québec, Canada, April 22 - 27, 2006). CHI '06. ACM Press, New York, NY, 466-471.
3. Ames, M. and Naaman, M. 2007. Why we tag: motivations for annotation in mobile and online media. In Proc. of the SIGCHI (San Jose, USA, April, 2007). CHI '07. ACM Press, New York, NY, 971-980.
4. Balabanović, M., Chu, L. L., and Wolff, G. J. 2000. Storytelling with digital photographs. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (The Hague, The Netherlands, April 01 - 06, 2000). CHI '00. ACM Press, New York, NY, 564-571.
5. Bederson, B. B. 2001. PhotoMesa: a zoomable image browser using quantum treemaps and bubblemaps. In Proc. of UIST (Orlando, Florida, November 11 - 14, 2001). UIST '01. ACM Press, New York, NY, 71-80.
6. Davis, M., Van House, N., Towle, J., King, S., Ahern, S., Burgener, C., Perkel, D., Finn, M., Viswanathan, V.,

- and Rothenberg, M. 2005. MMM2: mobile media metadata for media sharing. In CHI '05 ACM Press, New York, NY, 1335-1338.
7. Frohlich, D., Kuchinsky, A., Pering, C., Don, A., and Ariss, S. 2002. Requirements for photoware. In Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work (New Orleans, Louisiana, USA, November 16 - 20, 2002). CSCW '02. ACM Press, New York, NY, 166-175.
 8. Gargi, Ullas, 2002. Managing and Searching Personal PhotoCollections
www.hpl.hp.com/techreports/2002/HPL-2002-67.pdf
 9. Girgensohn, A., Adcock, J., and Wilcox, L. 2004. Leveraging face recognition technology to find and organize photos. In Proceedings of the 6th ACM SIGMM international Workshop on Multimedia information Retrieval (New York, NY, USA, October 15 - 16, 2004). MIR '04. ACM Press, New York, NY, 99-106.
 10. Harada, S., Naaman, M., Song, Y. J., Wang, Q., and Paepcke, A. 2004. Lost in memories: interacting with photo collections on PDAs. In Proceedings of the 4th ACM/IEEE-CS Joint Conference on Digital Libraries (Tucson, AZ, USA, June 07 - 11, 2004). JCDL '04. ACM Press, New York, NY, 325-333.
 11. Horvitz, E. S. Dumais, P. Koch. Learning Predictive Models of Memory Landmarks, CogSci 2004: 26th Annual Meeting of the Cognitive Science Society, Chicago, August 2004
 12. Huynh, D. F., Drucker, S. M., Baudisch, P., and Wong, C. 2005. Time quilt: scaling up zoomable photo browsers for large, unstructured photo collections. In CHI '05 Extended Abstracts on Human Factors in Computing Systems (Portland, OR, USA, April 02 - 07, 2005). CHI '05. ACM Press, New York, NY, 1937-1940.
 13. Kang, H., Shneiderman, B., Visualization Methods for Personal Photo Collections: Browsing and Searching in the PhotoFinder, Proc. IEEE International Conference on Multimedia and Expo (ICME2000), New York City, New York.
 14. Kirk, D., Sellen, A., Rother, C., and Wood, K. 2006. Understanding photowork. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Montréal, Québec, Canada, April 22 - 27, 2006). CHI '06. ACM Press, New York, NY, 761-770.
 15. Kuchinsky, A., Pering, C., Creech, M. L., Freeze, D., Serra, B., and Gwizdka, J. 1999. FotoFile: a consumer multimedia organization and retrieval system. CHI '99. ACM Press, New York, NY, 496-503
 16. Morris, M. R., Paepcke, A., Winograd, T., and Stamberger, J. 2006. TeamTag: exploring centralized versus replicated controls for co-located tabletop groupware. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Montréal, Québec, Canada, April 22 - 27, 2006). CHI '06. ACM Press, New York, NY, 1273-1282.
 17. Platt, John C. AutoAlbum: Clustering Digital Photographs using Probabilistic Model Merging, Proceedings of the IEEE Workshop on Content-based Access of Image and Video Libraries (CBAIVL '00), pp. 96, June 2000.
 18. Qian, Y. and Feijs, L. M. 2004. Exploring the potentials of combining photo annotating tasks with instant messaging fun. In Proceedings of the 3rd international Conference on Mobile and Ubiquitous Multimedia (College Park, Maryland, October 27 - 29, 2004). MUM '04, vol. 83. ACM Press, New York, NY, 11-17.
 19. Rodden, K. and Wood, K. R. 2003. How do people manage their digital photographs?. In Proc. of the SIGCHI (Florida, USA, April 2003). CHI '03. ACM Press, New York, NY,
 20. Rother, C., Bordeaux, L., Hamadi, Y., and Blake, A. 2006. AutoCollage. In ACM SIGGRAPH 2006 Papers (Boston, MA, July, 2006). SIGGRAPH '06. ACM Press, New York, NY, 847-852.
 21. Shen, Chia, Lesh, N. Vernier F., Personal digital historian: story sharing around the table, interactions, v.10 n.2, March + April 2003
 22. Shneiderman, B., Bederson, B. B., and Drucker, S. M. 2006. Find that photo!: interface strategies to annotate, browse, and share. Commun. ACM 49, 4 (Apr. 2006), 69-
 23. Wilhelm, A., Takhteyev, Y., Sarvas, R., Van House, N., and Davis, M. 2004. Photo annotation on a camera phone. In CHI '04 Extended Abstracts on Human Factors in Computing Systems (Vienna, Austria, April 24 - 29, 2004). CHI '04. ACM Press, New York, NY, 1403-1406.
 24. Zhang, L., Hu, Y., Li, M., Ma, W., and Zhang, H. 2004. Efficient propagation for face annotation in family albums. In Proceedings of the 12th Annual ACM international Conference on Multimedia (New York, NY, USA, October 10 - 16, 2004). MULTIMEDIA '04. ACM Press, New York, NY, 716-723.