Photohelix: Browsing, Sorting and Sharing Digital Photo Collections

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Abstract

In this paper we debut Photohelix, a novel interactive system for browsing, sorting and sharing digital images. We present our design rationale for such a system and introduce Photohelix as a prototype application featuring a novel visualization and interaction technique for media browsing on interactive tabletops. We conducted a user study in order to evaluate and verify our design. We will present our findings in this paper and discuss further implications for future development of such systems derived from our experiences with Photohelix.

1. Introduction

In recent years digital media formats have had tremendous success and impact in almost all aspects of life. Digital photography, for example, has practically replaced its analog counterpart. In response to this, a variety of software for browsing, organizing and retrieving digital media, and particularly photos, has been developed.

Most digital photo tools have been designed to efficiently archive photo collections as well as to retrieve specific photographs as fast as possible. Two strategies to achieve these goals have matured over time: First, advanced grouping methods [10, 13, 23] and/or zooming interfaces [1, 14] are applied in order to maximize screen real-estate and to show as many pictures as possible at one time. Second, search engines help users to retrieve specific photos in a more goal-driven way. Since photos are perceived through the content shown, effective search relies on textual annotations or tagging with automatically derived meta data [6, 31, 26, 34]. Tagging-based approaches are very popular for online sharing of pictures (e.g., Flickr.com, Zoomr.com). However, recent studies suggest that users are reluctant to make use of annotation techniques [25] and might not even want to perform query-based searches [18] in their own personal collections.

These approaches share one property: They have been designed and optimized for single-user interaction on standard desktop computers. The PC is not well suited for co-present collaboration since the size and orientation of standard displays impede face-to-face communication. Desktop systems mostly preclude mutual eye contact and body language, as well as other properties which are important for verbal and non-verbal communication. Furthermore, PCs lack the tangibility of physical media, which is also very important for co-experiencing photo collections [8, 15].

In contrast interactive surfaces, and interactive tables in particular, offer a compelling platform for shared display collaboration, allowing multiple users to interact simultaneously with a shared information landscape. Collaboration around interactive tabletops has attracted a great deal of attention recently [7, 11, 19, 28, 27]. While digital photo browsing has served as a scenario in tabletop research [29, 21, 22], to our knowledge no system is available that takes the peculiarities of the cognitive and social processes of photo handling into account.

In this paper we introduce Photohelix, our prototypical design for the co-located browsing, organizing and sharing of digital pictures on an interactive tabletop. We present our design rationale for tabletop photoware based on literature review and empirical observations. We also describe one implementation of the aforementioned design. Then we present the results from the user study we conducted to verify our design and implementation of Photohelix. Finally, we discuss our conclusions and how they might inform the future development of similar systems.

2. Existing Tabletop Interfaces

The technology for large interactive surfaces has rapidly matured over the last years. Interactive tabletop systems, in particular, have come close to the point where we can expect them to be productized and marketed, hence impacting our daily lives more significantly. This was also strongly confirmed by the recent announcement of Microsoft's "Surface Computer".

SmartTech's DViT [32] is a vision-based, direct-touch technology, which is commercially available and widely used in research [3, 33] as well as in commercial products such as interactive kiosks. Also commercially available is the DiamondTouch [5] tabletop, which also provides multiple simultaneous inputs with the added benefit of user identification. It is based on the capacitive sensing technology. Further research in the fields of capacitive sensing, frustrated internal reflection and optical flow analysis is driving technology even further forward [9, 24, 35] and opens up new and interesting opportunities for tabletop applications.

Several studies have been conducted to better understand the specific requirements and unique properties of interactive horizontal surfaces. Early work by Kruger et al. [16] helped to explain the role of virtual artifacts orientation for communication in tabletop groupware. Scott et al. [28] observed collaborative group work on both conventional and interactive tables and derived a set of guidelines for the development of tabletop systems supporting collaborative group work. A later study [27], which observed how people organized and managed the surface space on tables, reported the importance of separate regions for private information, public information and storage. Several other approaches have been presented to support the development of orientation aware systems [17, 30], which offer different techniques to automatically re-orient information artifacts and support explicit rotation of items to enhance communication and mutual engagement. Further research efforts have focused on visualization and interaction techniques that take these findings into account to improve collaboration and communication amongst members in a group [7, 11, 20].

Not surprisingly, the popular application field of digital photography has served as a scenario for tabletop research. Hinrichs et al. [12] have studied the effects of their "interface currents" on the collaborative use of photo collections. Morris et al. [22, 21] have explored how the orientation and distribution of control elements influence group performance on interactive tables using a photo tagging/searching scenario. An extensive body of literature about consumer behavior regarding digital (but also printed) photos has emerged in recent years [4, 8, 15, 25]. All studies confirm that users share a strong preference for browsing through their collections as opposed to explicit searching. Thus our goal was to support the *browsing* process and its associated activities.

The personal digital historian (PDH) [29] is a tabletop application that enables users to share pictures based on the four Ws of storytelling (i.e., Who, Where, What, When). However, to render this support possible the PDH requires an extensive set of meta data, which is seldom found in personal image collections (cf. [25]). With Photohelix we present our approach to support browsing, organizing (i.e., creating and maintaining long term hierarchical structures) and co-located sharing of arbitrary sets of pictures, without requiring cumbersome annotation of image collections.

2.1. Design Goals

Throughout the body of literature [4, 8, 15, 25], a set of typical activities performed with media collections can be found. Future applications should try to support these activities, which are: *1) Filing* - The task of sorting media into folders or albums. *2) Selecting* - A repetitive activity in which users go through their collections and decide which items to keep and which to get rid of. *3) Sharing* - Often the ultimate usage of media at the end of its lifecycle. This can be performed remotely via e-mail or websites but also (and preferably [4]) co-located for communication and storytelling, such as updating friends and family about recent events. *4) Browsing* - Users look at pictures from different time periods, possibly to revive old and forgotten memories.

While these activities should be supported by any photo software, it is worthwhile to take a closer look at how certain properties of hardware and software configurations might support or hinder the photo-handling process. Frohlich et al. [8] coined the notion of "photo talk," which was later picked up and further investigated by Crabtree et al. [4]. To summarize, photo talk refers to the process of looking at (physical) photographs with friends and family while explaining what is depicted on the photographs or sharing an anecdote connected to the captured moment. This process is highly unstructured and can include several parallel actions or sub-activities, such as viewers joining or leaving the room, passing pictures around or detailed explanation of certain pictures.

These activities are well supported by physical photos, which afford the kind of flexible interactions necessary for browsing and sharing images. It is, for example, very easy to pass individual or stacks of photos around in a group seated at a table. Furthermore, physical photos impart a sense of personality and engagement that digital images fail to deliver. Frohlich et al. [8] even report that users are "turned off" by looking at pictures on a computer screen. Tabletop interfaces have promising attributes that could help overcome some of these problems by mimicking the flexibility and tangibility of physical media while coupling these qualities with the advantages of digital photography.

To support the photo handling process effectivly we identified the following design goals.

Overview at all times Refers to providing users with a visualization that represents an entire digital photo library, but also conveys information about where to find specific images when needed. This can be done by appropriately sorting photos (preferably by time [25]) and/or automatically clustering them so that many pictures can be displayed at once.

Details on demand Means that an individual image can be quickly and easily retrieved for sharing or manipulation.

Support for temporary structures Allows users to create temporary collections of images that are important for storytelling and especially its epistemic component. A tabletop photo application should provide the means to quickly create (and dissolve) arrangements of pictures, not necessarily from the same group or folder. For example, a user might wan to call up a set of beach shots from different vacations or several portraits of one person over the years. This should not affect the media collections' long-term organizational structure.

Flexible spatial arrangements Help support the dynamic nature of photo handling [8] and demands that every element of the graphical user interface can be flexibly oriented and positioned. For example, such a system should not only be usable from each edge of the table, but also from each corner without problems. When handling photos, a walk-in-walk-out behavior is observed frequently. People will use the system from unusual positions and should not be hindered in doing so, nor should they disturb others.

3. Overview of PhotoHelix

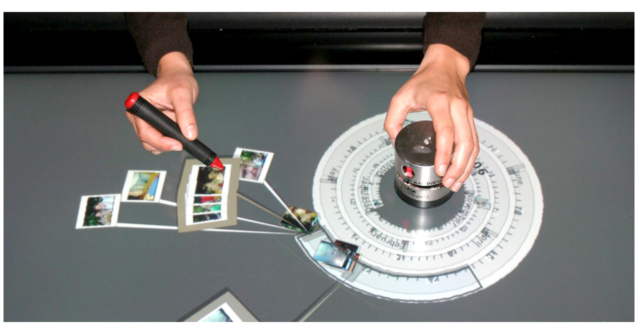

Figure 1. PhotoHelix with its physical control object on our interactive table

Photohelix is a spiral-shaped, time-based visualization of photo collections. In addition to this visualization, it provides tangible, gesture-based and bi-manual interaction techniques.

The system (see also Video[1]) was developed and deployed on a custom interactive table, which contains a 42-inch LCD display with a native resolution of 1360×768 pixels and an overlaid touch-sensitive DViT [32] panel for interactivity.

To fashion the physical control object, we disassembled an IKEA kitchen timer and equipped it with the electronics of a wireless mouse to measure rotation. Turning the upper part of the control object results in a standard mouse event that translates to the rotation of the helix. The position of the control object on the table is tracked by the DViT panel (see Figure 1).

Figure 2. A screenshot of Photohelix. The distinct functional areas (here: details above the helix, storage to the right) evolve dynamically and can be rearranged individually.

Photohelix was written in Java with a graphical presentation layer based on the University of Maryland's Piccolo framework [2]. We wrote an additional event-handling system that merges and interprets rotary encoder and touch events. These events are fed into a gesture recognizer, which enables gesture-based interaction with, and manipulation of, the photo collection and individual pictures. Metadata for individual photos, such as the capture date, is taken from the EXIF data.

3.1. Visualization

Tightly coupled to the physical control object is its virtual counterpart, a graphical visualization of the photo collection. It has the shape of a spiral and represents a timeline, on which the photos are organized, according to their capture date. Initially, photos are grouped into piles if they belong to a temporally continuous sequence (see Figure 2 on the left). This gives users an overview of their collection and supports orientation within the collection by narrowing down the search space.

The position and rotation of the spiral are controlled by the physical control object, hence it serves as a natural token to facilitate control allocation and turn taking in face-to-face communication and as a physical embodiment of the entire collection. The timeline is dynamically generated and

[1] www.mimuc.de/team/otmar.hilliges/files/ph.avi

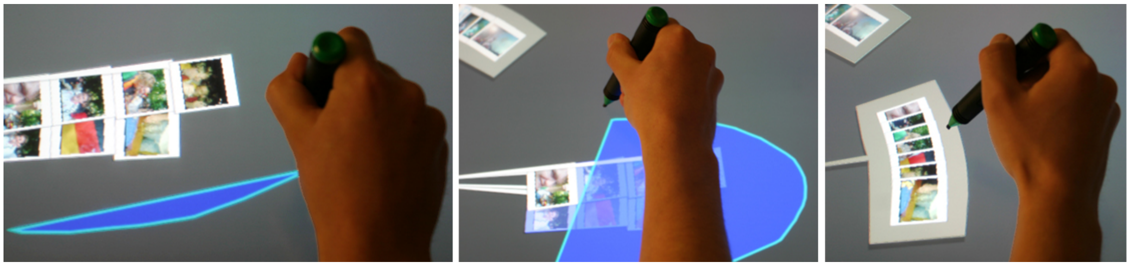

Figure 3. Grouping photos into a new event.

spans from the oldest image in the collection – placed in the center of the spiral, to the most recent image – placed at the outer end of the spiral. The inner spiral windings are shorter than the outer ones. This implies, that more space is available to place image piles in the outer, or newer, regions of the spiral. This nicely matches the observation, that people tend to take more photos with increased frequency over time. Furthermore, newer piles are depicted bigger and hence are easier to decipher. This also correlates with the observation that newer collection items are more frequently accessed than older ones [15].

Another component to Photohelix's spiral-shaped timeline is a semi-transparent lens that is overlaid on a certain section of the spiral. Pictures and piles of pictures that fall under the lens are shown in more detail thus providing "details on demand" (see Figure 2 above the helix). Photohelix works in two organizational forms: spatial arrangement and semantic grouping. Pictures are either shown individually (but arranged chronologically) or as so-called events. Events denote a stronger, more semantical coherence of the images therein and have to be created by the user (see Figure 3). Events are similar to folders in standard file managers. Each picture or event, when it falls under the lens, is called out and enlarged. It remains connected to the respective pile on the helix by an "umbilical cord". These images are again arranged chronologically along an imaginary line that runs parallel to the spiral's timeline. This leaves temporal relations intact and, in most cases, is equivalent to a semantic grouping, since temporal sorting tends to create spatial arrangements that are perceived as coherent [25].

3.2. Interaction

When the control device is set down onto the table, the spiral appears. For a few seconds, it remains semi-transparent and both the lens and the spiral rotate with the physical handle. During this time, a user can determine the initial position of the lens. Right-handers will, for example, move the lens to the upper right side of the spiral (see Figures 1, 2) so that they can conveniently turn the handle with the left hand, while using their right hand and a pen for interaction with the enlarged photos.

This mechanism also solves the general orientation problem by allowing each user around the table to adjust their Photohelix to best suit their needs (if several helices are available). It is also possible to reorient the whole interface at any time by just lifting it up, if several people share one helix or if the seating arrangement changes. To always ensure a comfortable working position, the helix can also be repositioned at any time by moving the physical handle to another spot on the table.

After the user has adjusted the initial orientation, the spiral is rendered solid and the lens remains fixed on an imaginary line running along the radius of the spiral. The spiral now turns with the handle, and the user can bring different areas of the spiral underneath the lens. The lens will travel inward and outward with the spiral windings, with every full turn applied by the user. To scroll faster, the handle can be twisted and then let run freely, to scroll back or forth several windings. The physical inertia of the handle in connection with a non-linear mapping of the time scale thus supports fast physical scrolling to cover larger time frames.

Individual images and events can be moved freely on the table surface, for example, when overriding the default chronological arrangement or organizing larger arrangements into sub-groups. To create events of closely related images, the user can simply circle the individual images with the pen. These are then automatically grouped into a new event, rendered as a slightly curved box containing semi-overlapping images (see Figure 3). New events also appear as new piles on the spiral and are connected to their pile by the umbilical cord. Cutting this cord dissolves the event again. To inspect the contents of events, the user can flip through the stack with the pen and see each individual photo in full (see Figure 4). This interaction technique resembles the handling of flip-books.

When a photo is dragged out of such a group, a full-size copy of the image is created and positioned on the table (see Figure 4, third image), which can then be moved with the pen or a finger. With the dedicated widget at one of its corners, it can be scaled and rotated (see Figure 5). This mechanism specifically supports the creation of temporary structures (e.g., several shots of the same person in

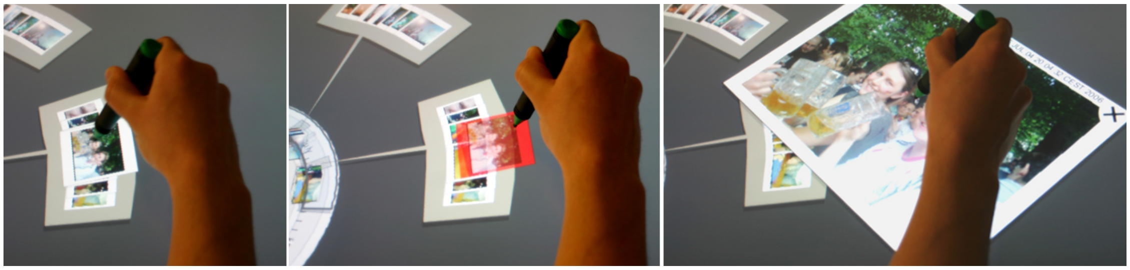

Figure 4. Flipping through an event to inspect images. Dragging images out of the event to create an enlarged copy.

one pile), without modifying the long term organization of the collection.

4. Browsing, Filing and Sharing

Browsing a photo collection can be done on different scales: Large-scale browsing indicates the act of going through a collection to identify a certain set of pictures. Small-scale browsing refers to inspecting events and images in more detail, for example, comparing several similar images to further use them for sharing or printing. Photohelix provides a convenient overview of the entire collection, structured by time. The automatic grouping of photos into piles of thumbnails serves two functions. First, the collection is presented in a space efficient way to avoid information overflow. Second, specific events or situations can be recognized on the basis of their representatives and the pile's position in time. Turning the helix brings different time intervals under closer inspection. Events and pictures displayed in the detail view (see Figure 2) convey more information to the user since all images are (at least partly) visible. This presentation is still very space-efficient, and also resembles the way in which printed photos can be spread out. Flipping through events allows a very fast inspection of large sequences. And the photos found while browsing, can easily be dragged out of the sequence in order to inspect the full-size version of individual pictures in further detail. The *filing* process is made more efficient by the automatic arrangement by time, and the ability to freely manipulate photos and events. This eliminates additional steps such as navigating folders. In many cases, the chronological sorting already meets the users' organizational intent. In addition, photos can be spatially arranged on the entire surface of the desk, which allows individual semantic mappings. For example one can create piles (e.g., left is for bad photos, right for good ones, top for funny, bottom for serious).

Figure 5. Rotating and resizing pictures in Photohelix.

Photohelix particularly supports the *sharing* of photos, in this scenario, showing the photos to the people around the table. For this purpose, they can be freely moved and rotated toward others. In fact, the individual arrangement on the table can be used to convey parts or the structure of the story to the observers. For example, users can create a heap of pictures close to their edge of the table. While telling a story they can subsequently move and orient currently discussed images toward the audience. Additionally, collaborators can pick photos up and further inspect them at any time. It is also easy to hand over the entire collection since it is represented by and linked to the physical handle.

The current implementation of Photohelix does not support the *selecting* activity. In order to support this, it would be mandatory to delete "bad" pictures. We experimented with several interaction techniques to delete pictures. However, all of them where prone to in-accurate or faulty input. Furthermore, we encountered difficulties in attaining "raw" images, since many users already performed the selection process during or directly after downloading images from their camera. For these two reasons we decided not to to support selecting.

5. Evaluation

To verify our design decisions, we evaluated Photohelix in a qualitative user study. We were specifically interested in whether our interaction techniques actively support the highly dynamic and informal activities associated with photo handling (described earlier in Section "Design Goals").

Participants Twenty participants (13 male, 7 female) between the ages of 18 and 34 were recruited from amongst our students and the local community. All of them had normal or corrected-to-normal vision and were right-handed. All participants were power users who worked on a PC for four or more hours daily. In contrast, most participants had little to no exposure to interactive surfaces (including PDAs and Tablet PCs). Only one participant reported an occasional usage of interactive whiteboards. All participants own a digital camera (33% use it 3 to 5 times a year, 48% take pictures once or twice a month 19% use it weekly or daily) and image collection sizes ranged from approximately 100 to 10,000 pictures (with an average of 3340).

Study Setup and Tasks We envisioned a scenario that includes elements of storytelling and picture-sharing, which required that participants be familiar with the images. Participants were therefore asked to bring a subset of their own collection. Typical image sets included 80 to 100 pictures from a time frame of approximately two years. They were also distributed over 6 to 8 different occasions (e.g., vacation, barbecue). While the size of these sample collections were not realistic, their distribution over occasions and time seemed to resemble real configurations (cf. [15]).

The four tasks were designed so that users would gain exposure to all aspects of Photohelix's functionality, and so that we could map tasks to the different activities identified in our requirements analysis. After completing an explorative warm-up task scaffolded with instructions on using Photohelix, participants were asked in Task 1 to *file* the images of their collections into events, thus permanently archiving the pictures. In Task 2 they should *browse* the entire collection and choose one particular event. They were subsequently asked to select one representative photo, enlarge it and explain why they had chosen it. Task 3 was aimed at *sharing* and participants had to give an update about a recent vacation. During the course of this process they were asked to enlarge several images and show them to the study conductor, who played the role of a friend or acquaintance. Task 4 was to choose four possible candidates from each of the four seasons to be used as the desktop wallpaper.

5.1. Results

In our experiments we gathered quantitative data (i.e., Likert-scale responses) as well as qualitative data from a semi-structured interview with open-ended fill-in responses. We also video taped every session and analyzed these recordings afterwards.

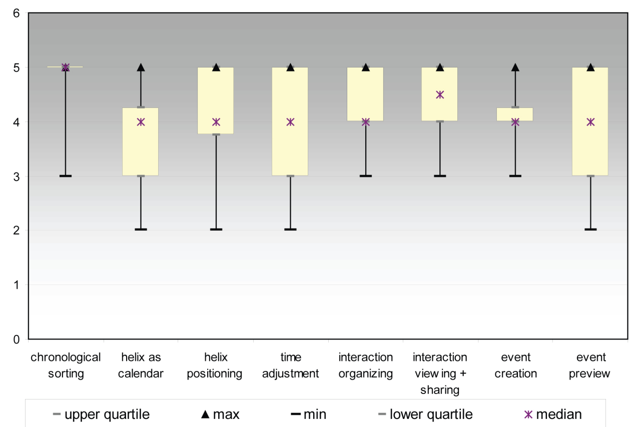

Figure 6. Appreciation of different functionalities in Photohelix. (Scale: dislike (1) – neutral (3) – appreciate (5))

We wanted to find out whether users liked our system, and which aspects were especially appreciated or needed improvement. To answer these questions we evaluated the responses to several Likert-Scale questions (Scale: disagree (1) – neutral (3) – agree (5)) as well as the free-form comments. In general people liked Photohelix (4.1/5) and thought it was "easy" and to use (3.7/5). They also liked the look and feel of the interface (4.2/5). Additionally, they thought that the visualization provides a good overview of the photo collection (3.9/5). When asked to rate specific functionalities of the system (See Figure 6), users liked the chronological sorting of pictures (4.85/5) and the visualization of time using a spiral-shaped calender (3.8/5). Furthermore, the possibility to freely position the spiral (4/5) and images (4.35/5) on the table received good ratings, as did the usage of the physical handle to adjust the time (3.85/5). Users appreciated the interaction techniques to create (4.1/5), flip through (3.7/5) and dissolve (4/5) events as well as the interaction techniques to rotate and scale images (4.3/5).

The qualitative comments we received further emphasize the above ratings. Several comments suggest that our design goals have had a positive impact. One participant said *"I like that all the pictures are already ordered by time. I like that I could see all the pictures quickly, just by turning the dial or flipping through the photos, and that I don't have to click into a folder in order to retrieve pictures."* Several other comments along these lines suggest that the *overview at all times* and *details on demand* paradigms are indeed beneficial for the browsing and filing activities. We also received many comments on the *flexibility* of the interface: *"... it was very intuitive, cumbersome copying of images becomes obsolete due to the possibility to create copies and* *temporal collections by simple dragging"*; and on its qualities for sharing: *"... browsing and viewing photos together is nicer with this kind of interface. It's more fun, too."*

Identified Issues Our evaluation also uncovered several shortcomings of the Photohelix prototype. The most frequent complaint (6 out of 20 participants) was that the thumbnails on the calender were too small, which made it difficult to recognize the possible contents of the group depicted by the thumbnail pile. Many users also complained that there was no shortcut to jump directly to a certain group of pictures or that twisting the physical knob (which we hoped could serve as a quasi-shortcut) was too inexact.

Some users did run out of screen space or suffered from visual clutter, because they did not make frequent use of the possibility to rearrange the interface configuration. To find out why, we reviewed the video recordings. While there was no statistical correlation between the described problem and the overall usage time in Photohelix, we still observed that users who spent more time in the exploratory phase started to make more frequent use of the features over time (i.e., creating piles of enlarged copies, re-positioning and re-orienting the helix). Further research is necessary to find out whether more experience with this kind of flexibility in the user interface would help in reducing visual clutter.

6. Discussion and Future Work

The results from our evaluation suggest that the current design provides several benefits for browsing, organizing and sharing (as in storytelling) digital photo collections. The physical handle serves as a graspable representation of the entire collection and the helix shaped calendar functions as a possible visualization that is coherent with most users' mental model of their collection. Thus the combination of the two provides effective means to access the collection and to retrieve individual pictures for further inspection. It seems that the flexibility of the interface, which allows users to create individualized arrangements of interface elements, might help to close the gap in emotional attitude toward digital photos versus their printed counterpart by creating a pseudo-physical experience.

However, our prototype also has several limitations which must be addressed before the system could be used under realistic (or close to realistic) circumstances. First of all, the current implementation does not support the *selecting* activity. This is partly due to the difficulties we encountered with unintentional input, which led to the unwanted deletion of pictures. Also, the interaction techniques that we had planned for this activity (e.g., crossing-out, moving-of-the-table) were not robust enough against this kind of faulty input. In the future we plan to experiment with different interaction techniques to delete information artifacts in tabletop interfaces.

Photohelix was designed and implemented in order to assess the validity of the identified requirements and our design considerations – not as a system working under realistic circumstances. Hence, scalability is an issue in the current state of implementation. We do not optically condense the information shown at any given time further than pre-grouping images into piles on the helix. Therefore, the current approach does suffer from visual clutter once these groups contain more than approximately 30 pictures each. This would be rather frequent under realistic circumstances, for example many pictures taken at a wedding (i.e., over a short period in time).

We plan to address the scalability problem in different ways, for example, by applying automatic clustering algorithms or by techniques that automatically adjust the zooming of the area where thumbnails and events are positioned. The overall size of the collection is also an issue, in order to maintain a good overview the size of the entire collection and the time difference between the oldest and the youngest events need to be balanced. Currently only a few hundred pictures, spread over approximately two years, are displayed in a satisfactory manner. A possible solution would be to render the timeline in a non-linear fashion to optimize screen real-estate while still conveying the temporal information.

Finally, we plan for the future to further support the co-located *sharing* of pictures by increasing the concurrency of the interactions. The biggest hurdle at the moment is the limitation of our hardware, which only allows two simultaneous contact points. Once more simultaneous contact points become feasible one could easily extend the current system so that it allows several users to exchange pictures from their personal collections, each represented by an individual helix.

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