

# TECHNICAL RESEARCH REPORT

Meaningful Presentations of Photo Libraries: Rationale and Applications of Bi-Level Radial Quantum Layouts (2005)

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# Meaningful Presentations of Photo Libraries: Rationale and Applications of Bi-Level Radial Quantum Layouts

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## ABSTRACT

Searching photo libraries can be made more satisfying and successful if search results are presented in a way that allows users to gain an overview of the photo categories. Since photo layouts on computer displays are the primary way that users get an overview, we propose a novel approach to show more photos in meaningful groupings. Photo layouts can be linear strips, or zoomable three dimensional arrangements, but the most common form is the flat two-dimensional grid. This paper introduces a novel bi-level hierarchical layout with motivating examples. In a bi-level hierarchy, one region is designated for primary content, which can be a single photo, text, graphic, or combination. Adjacent to that primary region, groups of photos are placed radially in an ordered fashion, such that the relationship of the single primary region to its many secondary regions is immediately apparent. A compelling aspect is the interactive experience in which the layout is dynamically resizable, allowing users to rapidly, incrementally, and reversibly alter the dimensions and content. It can accommodate hundreds of photos in dozens of regions, can be customized in a corner or center layout, and can scale from an element on a web page to a large poster size. On typical displays (1024 x 1280 or 1200 x 1600 pixels), bi-level radial quantum layouts can conveniently accommodate 2-20 regions with tens or hundreds of photos per region.

## Categories and Subject Descriptors

H.5.1 [Multimedia Information Systems] H.5.2.[User Interfaces] *Screen design (e.g., text, graphics, color)*

## General Terms

Design, Human Factors.

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## 1. INTRODUCTION

As digital cameras become ubiquitous, users have begun accumulating collections of thousands of pictures. Frequently users do not have the time for or interest in annotating these pictures, and they end up in the digital equivalent of the proverbial shoebox, never to be found or used again. In response, researchers are developing innovative interfaces to manage collections, encourage annotations, and facilitate browsing [11, 20].

Effective annotation (automatic, semi-automatic, or manual) could vastly expand the usability of photo collections, enabling improved search and meaningful layouts. Many tools have emerged on the market to aid in the annotation process [1, 2, 18]. However, the habit of regularly annotating photos, a requirement in museums and libraries, has yet to take a strong hold in the larger world of consumer-oriented digital photographers.

Contemporary photo library software allows users to define hierarchies of tags (for example, “Family” with subtags for each family member, or “USA” with subtags for each state), and allows sorting and selective display based on those tags. The final set of photos, however, is displayed in a flat rectangular grid, with no meaningful grouping based on metadata for the selected photos. Showing multiple groups tied to each tag would be a natural extension to these flat grid designs.

Similarly, customers using professional web sites for the growing market in stock photos could benefit from more effective presentations than the grid. Corporations such as Getty Images, PunchStock, Veer, and Corbis could make their search results more comprehensible and easier to browse.

Finally, museum, library, and research photo collections often limit users to viewing lists of photo descriptions or a single image at a time. Academic users and professional librarians could also benefit from enhanced presentations showing meaningful groups of search results for their image libraries.

The following sections contain screenshots of domains in which the approach of a bi-level radial quantum photo layout might be useful. Guided by user needs and available metadata, we discuss useful parameters in determining the layout, and appropriate properties for a creation tool. The techniques for determining photo size and layout are described here, while in-depth analysis of the algorithms is discussed separately [12].

## 2. PROPOSED APPLICATIONS

To demonstrate some of the possibilities, we show ten layouts, for personal and commercial applications. The screenshots are meant to be illustrative; users will be able to alter the design with regard to line weight, color, fonts, text content, etc. to suit their needs. These screenshots show the layouts, but the interactive experience is compelling; users can resize and reshape the windows, add or delete regions, or add more photos. The interactive experience may be one of the strong attractions.

The availability of useful metadata governs the potential for producing these enriched layouts. While timestamps provided by digital cameras are a good starting point, many researchers have hopes of providing much more automatically, semi-automatically, and manually. Automatic geographic location is likely to become a part of photo metadata by way of cell phone locators, Geographic Positioning Systems (GPS) built into camera, or other triangulation strategies. Content metadata may come from image analysis software, which could amplify the benefits of manual notations. For example, if the photographer annotates the name of a child at a birthday party, then image analysis tools are likely to be able to find other images with that child during the same time interval. Face recognition strategies are improving but image analysis strategies are far more effective in matching the color of a bright shirt or party hat, and occasional mislabeling can be repaired if an adequate interface is provided [22].

Content and theme labeling is more difficult to arrange automatically, however innovative solutions based on social network strategies may provide some solutions. One idea is to make a game of labeling or annotating web images [3]. Other emerging strategies are to take text that accompanies photos on web pages or in email as the basis for annotations [13]. The enormous growth of cell phones with cameras has led to annotation strategies that encourage data entry by cell phone [23] or posting the images to websites such as flickr, where web-based annotation becomes possible.

In summary, the desire for annotation seems strong, and technological solutions seem promising. These lightweight strategies may never equal the quality of annotation provided by professional photo librarians, but they may provide sufficient metadata to enable the visual presentations that we propose in the this paper.

The ten layouts we present were automatically generated using a program that implements the bi-level radial quantum layout algorithms, called BRQ-Layout. After a layout was generated from the photos’ metadata, adjustments were made to the final size and location of the primary region, as well as to the custom graphics drawn in the primary region.

### 2.1 Family Photo Collection

Figure 1 depicts a family layout, with the primary region showing a newly married couple and the secondary regions showing key family members. One region illustrates the capability of putting more than one tag in a single region (Simmy & Lani). The color of each region gradually goes from a brighter beige to a darker beige, to encourage the user’s eye to track radially clockwise from the upper left hand corner.

There are many photos in this view – to show fewer photos, users can choose to only show “Favorites”, or restrict by a secondary tag such as “Event” or by a date range (see later examples). Figure 1 contains similar quantities of photos for each region, which lends itself to a balanced view. Layouts with reasonably similar quantities can reduce wasted space, and with user manipulation of the size/position of the center region, create a layout which is efficient and attractive.

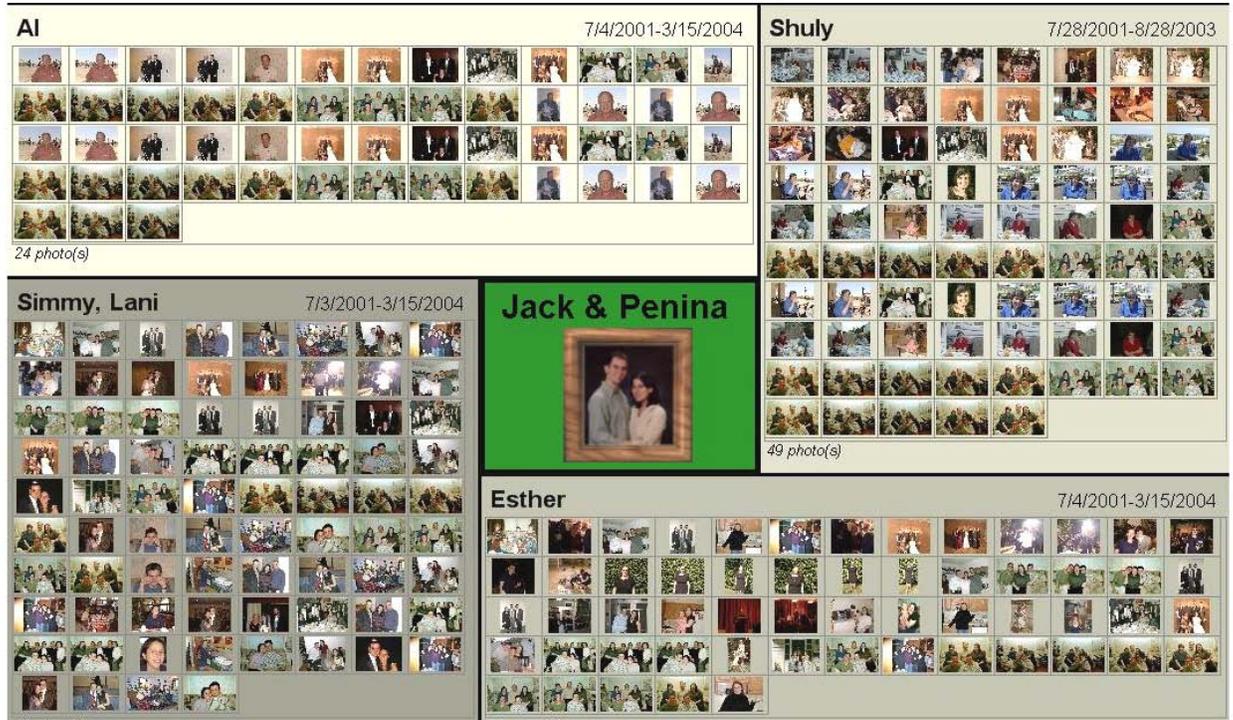
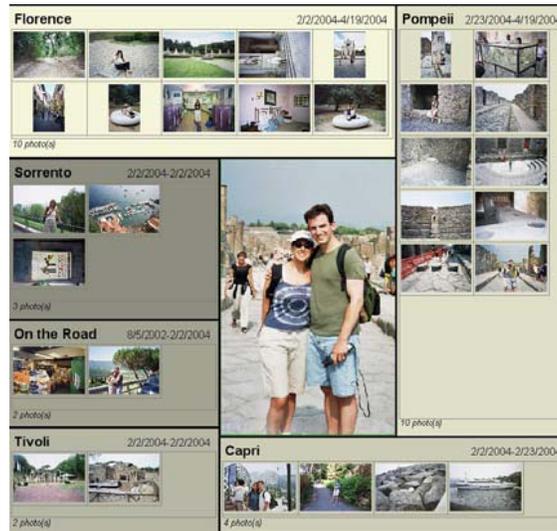


Figure 1: Family Photo Collection

## 2.2 Honeymoon Trip to Italy

Figure 2 depicts a generated layout of photos taken on a trip to Italy with a representative photo in the primary region. The generation software keeps the photo groups in the original order, so that the user can readily find a part of the trip that was towards the beginning, end or middle. This also prevents regions from moving around during dynamic resizing, which has been shown to be a distraction [21].



### Figure 2: Honeymoon in Italy showing 6 locations during a two week trip

In this case, all photos are shown. As in the Figure 1, dates are shown that reflect the creation date of the photos. This provides a calendar perspective on the layout beyond the implied ordering.

Strategies for handling geographic metadata are being refined rapidly so that photos in the same area will get labeled with appropriate and meaningful names [17].

### 2.3 Faculty of UMD CS Department

Moving away from family photos, Figure 3 shows a primary region with the chair for the University of Maryland Computer Science department. Secondary regions (6 in this case), contain a photo for each faculty member in each research area. To generate this layout, groups of photos were annotated with the correct department and research area. In this case, individual captions would be helpful, potentially drawn from faculty name annotations.



Figure 3: UMD Computer Science Department with 6 research areas

### 2.4 Real Estate Browser

Figure 4 presents a hypothetical real estate web site, containing a hierarchical photo layout within a web page. The primary region gives the identifying information about the real estate agency and the secondary regions show search results by city. As users change the size of the browser window, the regions and photos all resize dynamically to allow for the largest photo possible given the number of photos in each region. This strategy extends the now common re-flowing of text on window resize to photo layouts. Any of the photos could be clickable, leading to more information about that house, and each label and/or region could link to more information about that locale, for example “College Park”. The title for each region shows the price range of the displayed houses, thus providing more information about the visible houses at a glance.



**Figure 4: Real Estate Browser with 5 communities and the price ranges of selected homes**

Should a new house come on the market in College Park, Olney, or Silver Spring, it would fit nicely in the blank space under the seven houses currently visible. A new house in one of the other regions could push the photo size smaller, or might instead cause the secondary regions to be distributed differently about the primary region, possibly without requiring smaller photos.

Creating a commercial tableau like this one is possible with existing tools, but requires extensive cutting and pasting, and constant re-adjustment of the photo sizes. The ability to dynamically create such a layout provides the page designer with a new expressive power to convey relationships between images, and gives users the real-time ability to get photo-based feedback on filtering operations.

## 2.5 Magazine Table of Contents

Sometimes there is a need to show a graphical overview of a publication, to create a large billboard at a book signing or as a navigation tool on a web page. Figure 5 shows such a layout for an edition of *ACM Interactions* magazine, with the first page of each section. Page numbers of each section could be added to each region.



Figure 5: Magazine Table of Contents with the lead page from 8 articles

## 2.6 Magazine Contents (Left)

In addition to the radial layouts seen thus far, the main region can be located in one of the corners, or in a column along one side. Figure 6 presents the magazine layout again, this time with several pages from each section, and the magazine cover in the left hand margin. As suggested in the previous screenshot, page numbers for each section of the magazine were added to each region.

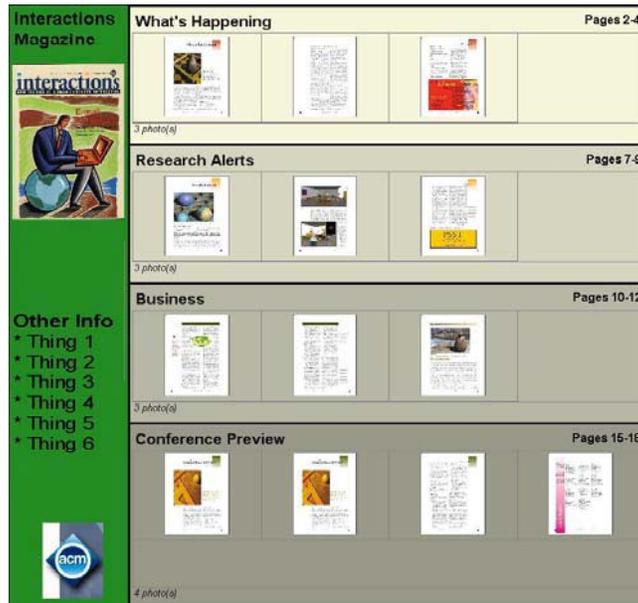


Figure 6: Magazine Table of Contents (Left)

## 2.7 Child With Parents (Left)

Figure 7 is another example of the left hand layout, this time showing a child with his parents to his right. As the number of photos grows, producing smaller thumbnails, users could limit the collection to favorites, a date range, or other criteria. Alternatively, to preserve larger thumbnail size, scroll bars could appear in each region to help navigate the collection.



Figure 7: Child with Parents

## 2.8 Siblings (Left Corner)

Figure 8 suggests a layout of all of the siblings in a particular family, where the primary region photo is chosen by the user as being representative of the collection. The number of secondary regions below the photo vs. to the right is chosen automatically, so as to maximize the thumbnail size (which depends on the relative placement of the secondary regions). The layout generation program allows users to dynamically adjust the size of the primary region, and to override the default choice of region placement.



Figure 8: Sibling Photos

## 2.9 Child's Narrative of an Event (Left Corner)

The photo layout could be done by a child as well as an adult, within the context of a child-centric user interface. In Figure 9, the photos are placeholders (in that they were not taken during a<sup>th</sup>

of July barbeque), but one could imagine an event tag "4<sup>th</sup> BBQ" being associated with a collection of two dozen photos or so, which are additionally tagged with the names of the people in them. With the help of an appropriate interface, children could create a poster, greeting card, or piece of artwork that placed and sized the photos automatically and then they could put more time and energy into the primary region's content. As a creativity support tool, the ability to automatically choose an optimal layout lets a designer, whether a child, adult, professional photo librarian, or hobbyist, spend time only on the creative part of the process by handling the calculations of thumbnail size transparently in the background.



Figure 9: Child's Photo-Based Narrative

## 2.10 Wedding Souvenir (Left Corner)

Following an event (wedding, birthday party, or other family celebration), customized cards or 8x10 collages could be distributed to guests. Figure 10 suggests a wedding souvenir, in which all the photos of one guest and the three women that he danced with are shown in an organized layout. While the photos shown are once again not representative in content, one could imagine a photographer generating layouts like these for all of the immediate family members.



As another example, a layout of all of the table photos (one table photo per region, for 10-20 tables) might be of interest to the bride & groom, as a way to see all of their guests on one layout, organized by where they sat. If instead of one table photo per region, *all* table photos were shown in each region, the layout might provide a convenient way to choose a “best table photo” for each table (for a fancy album, for example), comparing table photos of the same table and also photos of other tables.

## 3. GENERATING A BI-LEVEL RADIAL QUANTUM LAYOUT (BRQ-Layout)

The BRQ-Layout algorithm is capable of reading an annotated collection of photos and dynamically generating a photo layout. The goal is to present a primary region that conveys a message about the selected images plus a set of secondary regions that are meaningful components of the collection. The collection can have an internal hierarchy, or it can be set by the user from within the program.

### 3.1 Automatic Requirements

BRQ-Layout must be capable of the following automatic operations with real-time user response:

**Read a Collection** – This can be any collection of photos that has been annotated either manually or using an automated tool.

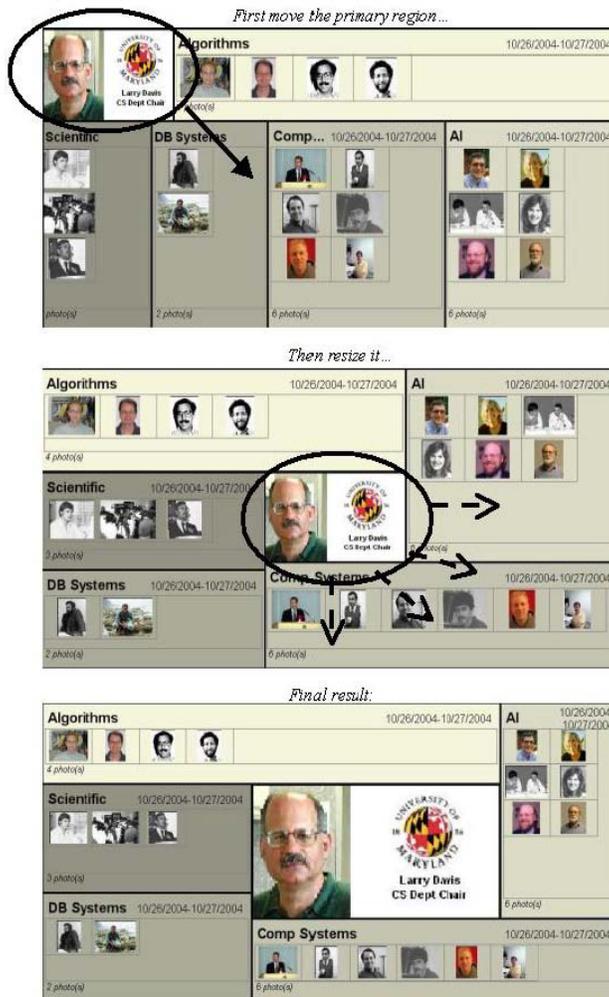
**Dynamically Add/Remove Ordered Photo Groups** – As users add tags, photos corresponding to those tags (optionally only photos labeled as “favorites”) are added to the layout, in the optimal position and with the maximal thumbnail size.

Order should be preserved, so (for example) if users add tags A, B, C, D, E -- C and D should always be adjacent. Removing a tag causes all other regions to reflow to maintain maximum thumbnail size.

**Dynamically Drag/Resize the Primary Region** – A strong component of the appeal of this interface is the capacity for users to play with the layout by dragging the primary region around the screen and then resizing it. This aspect of user control enables users to change the emphasis on the primary region, giving it less prominence to highlight the secondary regions or enlarging it to make it dominate. Figure 11 shows the results of first dragging and then enlarging the primary region.

**Dynamically Resize the Entire Window** – Users can play with the size and aspect ratio of the entire window that frames the primary and secondary regions. Users with larger size screens could enlarge the window to allow for more and larger thumbnails in each secondary region. Users may also alter the aspect ratio to get square (Figure 2), landscape (Figure 3), or portrait (Figure 4) layouts to fit their screens or create a desired graphic style.

The requirement for rapid response (as close to 100msec) ensures a high degree of user control and engagement. This means that backtracking algorithms that run in  $O(n^2)$  would not be acceptable. Satisfying the numerous constraints to provide pleasing layouts with large thumbnails, and little blank space became a programming challenge. The additional requirements of coping with varying numbers of images in secondary regions added to the challenge. Typical optimization methods, such as gradient following to find local optima, had to be abandoned because of the quantum nature of images. Small changes in size of regions or thumbnails gave radically differing results. Such unstable behaviors usually typically produce np-complete problems which a provable insoluble, so we made numerous heuristic choices to guarantee rapid, although possibly suboptimal, solutions.



### 3.2 Customization Support

Another requirement was to integrate user control to ensure customization needed for a particular application. Users can

perform the following actions via a direct manipulation interface:

Change the height & width of the overall layout    Change the height & width of the primary region    Change the position of the primary region    Change contents of primary region    Add, remove, and edit text captions    Add or remove single or multiple photos, or entire

regions As users make these modifications, thumbnail size and position are updated automatically, maintaining the optimality constraints that they had when they were first added. The goal throughout is to allow the user to create interesting designs that illustrate the relationship between groups of photos, while freeing the user from thinking about optimal thumbnail size and distribution about the primary region. The result is a fluid experience of photos flowing and resizing that resembles the response of a word processing program as an image is moved around the page as the text reflows around it.

#### 4. CONSTRAINTS

The Bi-Level Radial Quantum Layout (BRQ-Layout) is a tightly constrained two-dimensional surface. The quantum nature of photo sizes means that small changes to region sizes dramatically affect layouts and that there will be some blank spaces in most secondary regions. Among our many assumptions was that thumbnails in all secondary regions would be the same size. The algorithms that maintain and balance these constraints are covered in detail in [12]; a brief description of some of the interactions and tradeoffs is presented here. First, we define the following terms:

**Secondary Region:** A region is a logical grouping of photos, most likely because they share a tag.

**Primary Region:** The top level of the hierarchy, of which all secondary regions are logical children.

**Quadrant:** The area surrounding the primary region in the center layout is divided conceptually into 4 quadrants (see Figure 12 below). Each quadrant contains one or more secondary regions.

For a given overall length & width, the first decision the user makes is the size and location of the primary region, as this constrains several other variables. If the primary region is placed such that thumbnails will be below a minimum size (configurable), it will snap to the closest side, generating a side- or corner- layout (Figures 6-10).

Once that choice has been made, the parameters described in Table 1 interact in disturbingly complex ways.

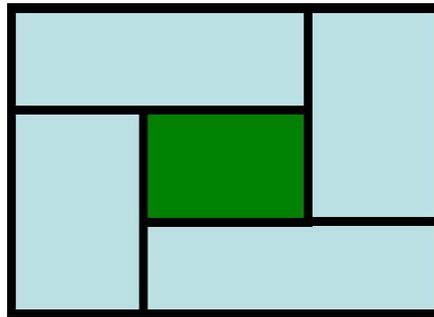
**Table 1**

Parameter	Determined By	Directly Influences
Primary region size and placement	Window dimensions (default), user customizable	Placement of secondary regions
Number of secondary regions	Number of tags chosen from the photo collection	Placement of secondary regions
Number of photos in each secondary region	Photo collection (user chooses “all photos”, “favorites”, or some other constraint, such as date range)	Placement of secondary regions, photo layout (rows & columns), photo size
Placement of secondary regions	Number of photos that will fit in each secondary region, primary size & placement	Photo layout (rows & columns)
Photo size	All other parameters	Photo layout (rows & columns)
Photo layout	Photo size	Photo size

The photo layout is both

determined by photo size (smaller photos enable placement of more on a row, for example), and determines photo size (a decision to have only 1 row forces small photo size in order to fit in the region). Since all other parameters influence photo size, all parameters are pulled into this non-linearity, forcing a high degree of algorithmic complexity.

An important constraint was added that there be only four quadrants (Figure 12). This was to make the layout cleaner by allowing only rectangular regions, preventing C and L shaped regions, with the accompanying user difficulties of figuring out the directionality of rows, etc.



**Figure 12: Four quadrants that can be used to hold multiple regions**

If there are four or more secondary regions, they will be distributed as evenly as possible in the four quadrants. (For fewer than four secondary regions, or when the primary region is along an edge instead of in the center, a modified algorithm is used.) Once the secondary regions have been placed in the proper quadrant, the relative size of each region within the quadrant is set based on the number of photos in that region. A photo size is then chosen which is guaranteed to be an upper bound, and reduced incrementally until no quadrant has overflow, i.e. photos that are too big for the region. As these are simple calculations and the photo width/height, number of photos, and number of regions are small and finite, the algorithm can proceed in time that is linear in the worst case.

The layouts can become problematic if there is one ratio with substantially more or fewer photos than another, for example 5 regions of 2, 3, 5, 60, and 4 photos each. In this case, scrollbars may appear in one or more region in order to prevent the creation of tiny thumbnails to accommodate the largest photo set. This modification will allow the algorithm to scale to photo collections that are not as balanced as those shown in the figures of Section 2.

While the layouts generated are optimal in the sense of maximizing thumbnail size,

future work could explore allowing users to override the automated choices, either to make improvements (if possible), or to be convinced that the layout is indeed optimal. These overrides might include changing which secondary regions get placed in which quadrant, the relative region sizes within a quadrant, and the thumbnail size. These increased choices should give users more of a feeling of control over what is currently an automated process.

In such a model of increased user control, users could also explore reducing or eliminating some of the constraints discussed in this section, for example allowing thumbnail sizes to vary per region, or setting a maximal number of thumbnails beyond which a scrollbar would be shown.

## 5. USABILITY EVALUATION

To gauge user responses to these bi-level radial quantum layouts we asked four knowledgeable users of photo library software to review our interface for 30-40 minutes each. In this modest usability study, they were shown the on-screen, but static layouts in Figures 1-4, in order and asked what they understood about the layout and relationship among the regions in each Figure. They responded positively, easily recognizing that the secondary regions were “closely associated” with the primary region, and appreciating the aesthetic value of a novel presentation of a photo collection. The color gradient was successful in suggesting the order of the radial sequencing, especially when combined with a second cue such as alphabetized region captions. They were happy with the generated layouts as a way to see a filtered view of a photo collection, although some suggested that a more traditional, linear approach might be more efficient for search-related tasks.

Then we asked them to drag and resize the primary region, exploring possible layouts. Our goal was to understand if they grasped the degree of control and could make satisfying choices. These four users understood the principles and readily dragged and resized the primary region. They also tried clicking on thumbnails in the secondary region, suggesting an implied invitation to interact with the collection and not just view it as a final, generated presentation. Although they understood the dynamic thumbnail resizing (one user reported noticing only “large” or “small” thumbnails), they were sometimes surprised by the appearance of larger blank spaces and seemingly smaller-than-needed thumbnails, and all four requested an option to relax the constraint of equal thumbnail sizes at user discretion, so that the space could be better utilized. All users reported a preference for larger thumbnails whenever possible.

With experience they came to understand the possibilities and were delighted with the capacity to create their own arrangements. One user said, “Ahh! There we go!” as she started moving the central region around, and later said that she would love the tool for what she’s currently working on. Another reported some uncertainty in how to visually scan the radial layout, especially in the context of a search task. All four spent time moving the primary region around and watching the photos resize and rearrange, coming up with novel arrangements not described in this paper such as full-height primary region with left & right columns, and top-middle primary region surrounded by the secondary regions in a U formation.

In summary, this modest usability test confirmed our belief that organizing photos into meaningful regions was beneficial. When the text labels and color gradient clearly indicated the grouping and sequencing, users were appreciative, but without such cues they struggled to grasp the sequencing. The users clearly desired additional interactive features such as clicking photos to get more information, selecting a photo to be the primary region, and moving photos across regions.

## 6. RELATED WORK

There are several commercial applications that allow photos to be quickly tagged and organized. Adobe PhotoShop Album [2], for example, presents a grid of photos containing photos with selected tags or from a given date range. While useful, this view contains no notion of a hierarchy, nor is there a primary region, and it is not intended to be printed or otherwise distributed. Since temporal clustering is such a key aspect of personal photo library retrieval [7], PhotoShop Album includes a timeline viewer to allow users to select by time period. A grouped view of the temporal clusters with BRQLayer could enhance presentations of temporal clusters.

Several web-based photo tools (Yahoo, Ofoto, and Snapfish, among others) allow sharing, slideshows, grids, and linear strip versions of the photo collections. Again, once users choose a subset of photos, all visible photos are on the same conceptual level. A review of home-based photo albums provides further support for the utility of viewing search results that are grouped by content features and by contexts [16].

According to [19], there is a benefit to laying out photos based on visual similarity, although that study dealt with visual

similarity instead of similar contents. Our generation software takes their suggestion to incorporate captions and labels where possible, and not to rely solely on the grouping to convey the meaning of the divisions between areas of the layout.

Quantum Treemaps and Strip Treemaps [4] similarly group photos into categories, and lay them out dynamically in a way similar to that described in this paper. The layouts described in that paper are not hierarchical, however, and layout is done in a linear, top to bottom fashion, instead of the radial style described above.

Adaptive Layout is a technique already in use for document layout [8], in which constraints are defined, and then an algorithm generates page layouts that meet as many of those constraints as closely as possible. The text flow around pictures described in that work is similar to the flow of photos around the primary region in BRQ-Layout.

The output of BRQ-Layout is a collage of sorts; various other collage-generation packages do exist [6, 10]. These layouts strive to be artistic and visually interesting, but do not convey a hierarchical relation. While BRQ-Layout's layouts should be visually appealing as well, they have a practical goal which goes beyond the scope of these other collage generators.

The WeightMap is a technique for evaluating the visual balance of an automated layout [14], and it is helpful in deciding placement of images of different brightness and color within a layout. While BRQ-Layout's sequence of rectangles is dictated by users, the ordering of photos within a rectangle could be decided by the WeightMap or other techniques [5]. This might be an interesting user option that would increase the visual appeal or usefulness of the generated layouts.

Elastic Windows [9] is a browser that creates multiple hierarchical windows within the program as the user visits different web sites, with the goal of reducing disorientation and cognitive overhead. The hierarchical rectangles generated through usage resemble the secondary regions produced by BRQ-Layout, as does the dynamic layout as regions are added and removed.

## 7. CONCLUSION

This paper motivates a novel design of a two-dimensional bi-level radial quantum photo layout. While many tools exist for generating layouts dynamically, BRQ-Layout creates layouts with an immediate and intrinsic hierarchical relationship between a primary region and its secondary regions. This layout has interesting applications for personal photo libraries, allowing parents to be surrounded by their children, as well as for commercial applications, as in a magazine table of contents or a real estate browser.

Since layout is automatic, these layouts demand minimal effort by users, while providing the ability to customize if desired. And since the layout is dynamic, the algorithms are well suited to a web environment, allowing photos to reflow layouts in a way that is analogous to dynamic text reflow when the browser window is resized.

Further work is needed to refine and test the algorithms with varying browsers, screen sizes, and metadata annotations. While utility with small libraries and small result sets seems clear, scaling up to large libraries, complex metadata, and larger result sets provides further challenges. Semantic web ontologies could provide another natural structure to organizing photo library search results, facilitating richer generated presentations.

Feedback from our usability evaluation suggests relaxing some of the constraints such as constant thumbnail size, in order to give the largest possible image. Future work might provide greater interactivity at the region level, allowing full direct manipulation of all elements of the layout including region size, color, and labeling. The interactive nature of the layout gives users a compelling sense of control as they playfully explore the layout possibilities.

## 8. ACKNOWLEDGEMENTS

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