TiDi Browser: A Novel Photo Browsing Technique for Mobile Devices

Gerald Bieber[a], Christian Tominski[b], and Bodo Urban[b]

[a]Fraunhofer Institute for Computer Graphics, Joachim-Jungius-Straße 11, 18059 Rostock, Germany

[b]University of Rostock, Albert-Einstein-Straße 21, 18059 Rostock, Germany

ABSTRACT

Today's digital photos can be tagged with information about when and where they were taken. On stationary computers, this information is often used to drive photo browsing. This is not the case for mobile devices.

We describe first results of our current research on a novel photo browsing technique called TiDi Browser. TiDi Browser exploits time and location information available in digital photos to facilitate the identification of personal events and the detection of patterns of specific occurrences in time and space. Along with a main view and thumbnail previews, our browser application provides two time lines. One time line visualizes the number of photos taken per temporal unit (e.g., day, week, etc.). This allows users to easily detect personal events in time. The second time line visualizes location information. Since two- or three-dimensional locations are difficult to represent on small displays, we reduce the location information to one-dimensional distance information. The distance is shown in the second time line. Both time lines serve a second purpose as graphical user interface, meaning that they can be used to browse in time. Even larger photo collections can be browsed on very small displays intuitively and efficiently.

We implemented our ideas in an interactive prototype that uses a client-server-architecture. To save bandwidth, we transmit appropriately scaled photos that fit the display dimensions of the client (mobile device). To enhance the user's browsing experience, we apply caching and prefetching strategies.

Keywords: Photo browser, mobile devices, time, location, GPS, personal events

1. INTRODUCTION

In recent years, mobile computing devices like PDAs (Personal Digital Assistants) or cell phones have become increasingly popular. This is not only due to their improved performance, but is also caused by the new capabilities and connectivity of such devices (e.g. WLAN, UMTS, Bluetooth, GPS, etc.). Moreover, mobile devices have gained the capability of taking photos of satisfying quality. Today it is possible to take photos in any situation, anytime, and anywhere. Consequently, users take more and more photos for their personal photo libraries. On the other hand, today's PDAs have high resolution full color displays and the possibility to connect to the Internet. This makes them excellent tools to access personal photo libraries, and to show or present the taken photos anytime and anywhere.

In this paper we will present a novel photo browser for mobile devices called TiDi Browser and its integration into a client-server-architecture. The presented browsing technique exploits meta data commonly preserved in digital photos, i.e. information about when (time) and where (location) a photo was taken. This enables us to provide users with new insights into their photo-taking behavior, and also to provide a novel interface for browsing the personal photo library. The need for intuitive photo browsing techniques will increase in the future, because new photographic devices (e.g. mobile camera phone worn as necklace) will take more and more photos automatically.

Further author information: (Send correspondence to Gerald Bieber)
Gerald Bieber: E-mail: gerald.bieber@igd-r.fraunhofer.de, Telephone: +49 381 4024 110
Christian Tominski: E-mail: ct@informatik.uni-rostock.de, Telephone: +49 381 498 7450
Bodo Urban: E-mail: bodo.urban@igd-r.fraunhofer.de, Telephone: +49 381 4024 110

In Section 2 of this paper we will briefly review previous work related to this topic. Our novel photo browser for mobile devices is introduced in Section 3. In that section, we will also describe the client-server-architecture in which the TiDi Browser is integrated. A conclusion and an outlook on future work are given in Section 4.

2. RELATED WORK

The advances in digital photography have led to a situation where many people take lots of photos every day. For this reason, it is common that users have personal photo libraries on their home computers. For desktop PCs, various software applications can be found that support users in managing as well as browsing such photo libraries[1] (e.g. Google's Picasa or ACDSee 8). While simple tools are often based on presenting grids of thumbnails and providing a detailed view on demand, more sophisticated approaches utilize special layouts of thumbnails and provide extensive query and browsing methods.[2,3]

Another aspect of digital photography regards the availability of meta data automatically stored within photo files. Information on camera settings (e.g., shutter speed, ISO, etc.) are valuable for postprocessing purposes. Further meta data may be added later to store personal information along with photos.[4] As described in Graham et al.,[5] the time when a photo was taken is particularly useful for browsing personal photo libraries. Moreover, the availability of mobile devices with integrated GPS receivers (e.g. Motorola A780) and the possibility of connecting digital cameras to external GPS receivers[6] allow storing location information (i.e. where a photo was taken) within digital photos. First approaches to visualize where photos were taken mainly focus on presenting them superimposed on maps[7–9] (e.g., plugins for Google Earth). Both temporal and spatial information facilitate an automatic organization of photo libraries.[10]

Not only photo cameras have improved capabilities. Mobile computing devices have also increased in their functionality. The hardware of older Palm and WinCE computers as well as mobile phones did not really support the joy of photo browsing because of low color depth and limited display resolution. Nowadays, devices like the mobile phone Nokia 7710 or PDAs with true color and VGA resolution (480×640 pixels) are state of the art. Various technologies allow access to the Internet (e.g. WLAN, UMTS, GSM). However, the available standard photo viewing applications on mobile devices are rather simplistic; interaction and searching capabilities are limited[11] and browsing remote photo libraries is not supported. With the availability of temporal as well as spatial meta information, new possibilities open up for browsing and querying personal photo libraries on mobile devices. Whereas searching for photos with specific time and location by utilizing standard search forms can already be realized on mobile devices,[12] a visual representation of the location information is still difficult to achieve, and thus, not yet considered on mobile devices.

The advantages of utilizing the newly available meta information and hardware capabilities for photo browsing on mobile devices are still underestimated.[11,12] In the next section, we will demonstrate how time as well as location information and its correlation can be exploited to drive an intuitive visual interface for browsing a personal photo library on mobile devices. We do not limit ourselves to photos located on a mobile device, but intentionally support the real world scenario where all photos are located on a home PC or personal server environment.

3. TIDI BROWSER

3.1. Considering Photo Taking Behavior

The behavior of people taking pictures either with analog or digital cameras differs. Since the costs of taking analog pictures are determined by costs for film and development, only a few but good images are taken. Digital cameras allow a very inexpensive production of photos. The price is set only by (low) storage costs. This leads to a free and undisturbed photo-taking behavior that is dominated by the wish of catching the personally relevant moments in a still image or a video clip. This wish is reflected in most personal photo libraries. Therefore, an analysis of the personal photo-taking behavior can reveal interesting relations between relevant personal events. For instance, an analysis of the photo accumulation over time reveals interesting pattern. On the one hand, relatively short termed time periods with a higher number of photos indicate important personal moments (e.g. a wedding, birthday, etc.). On the other hand, a longer time period with a rather constant but smaller number of photos indicates for instance a vacation, a weekend trip, or a three day visit of friends. Even a short photo

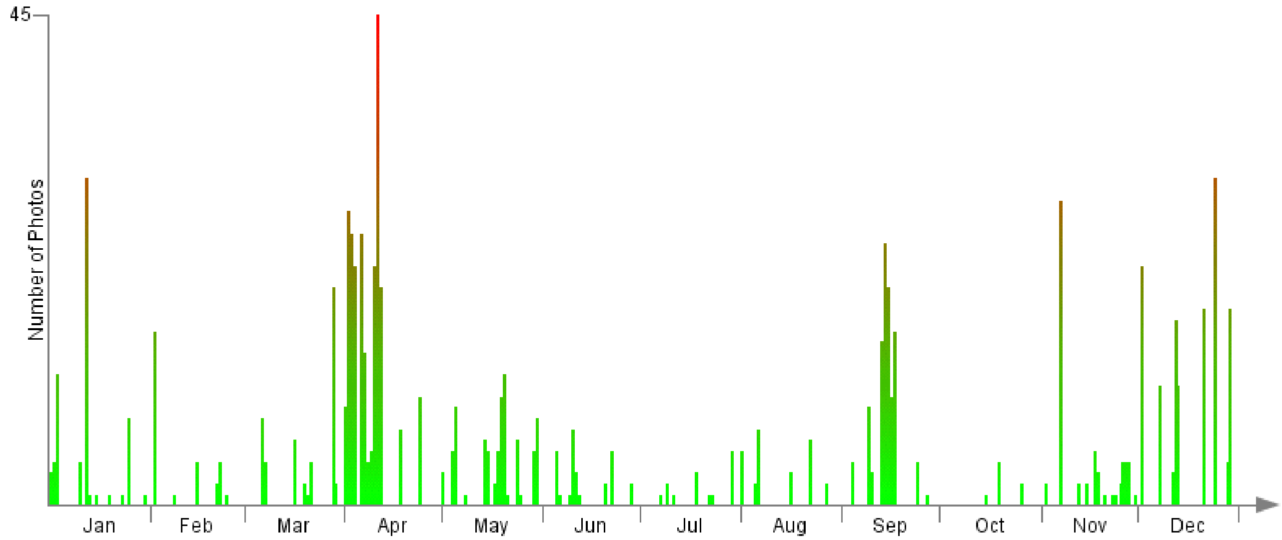

Figure 1. Photo frequency over a period of one year – Large numbers of photos taken at the beginning of April as well as in September clearly indicate personal events like vacation. Towards the end of the year, several spikes also give evidence of some events.

series taken within less than a minute can be a pointer to a highly relevant situation (e.g. the person wanted to make sure to capture the situation from different points of view).

Figure 1 illustrates a real dataset of a person's photo-taking behavior as a photo frequency chart; time is mapped on the horizontal axis, the number of photos on the vertical axis. The figure shows about 900 photos taken over the period of one year. Several high spikes depict relevant personal events. In this particular examples, the spikes depict events like birth days or trips. Occasionally, spikes also indicate unfortunate happenings like car accident where many photos were taken for documentation purposes. In Figure 1, major accumulations of photos can also be found at the beginning of April and in the middle of September. As indicated previously, these accumulations depict longer termed happenings (vacations in this case).

It becomes clear that certain visual patterns in the representation indicate certain types of personal happenings. Therefore, a visual representation of the photo-taking behavior (e.g. a as a frequency chart) could foster a mental map of a personal photo library. Once such a mental map has been established, users can easily recall certain constellations in their personal life. Moreover, searching and browsing in photo libraries is facilitated by a mental map.

3.2. Time- and Distance-Based Photo Browsing

In this section we will introduce TiDi Browser. We assume that the concept of integrating visual representations of the photo-taking behavior might be very useful. The concept of visualizing photo frequency and information about the locations where photos were taken as well as the possibility to display additional associated meta data (e.g. content description, keywords or categories) should lead to a powerful browsing tool especially for mobile devices.

It was our aim to provide efficient mobile access to photos stored in a personal photo library. To achieve this aim, special attention must be paid to the limited display space available on mobile devices. We decided to dedicate as much space as possible to the presentation of photos. On the other hand, it is also necessary to provide textual information as well as user interface elements, which enable interactive browsing of photos. Therefore, a high integration of information presentation and direct manipulation[13] was pursued. That is, we provide views to represent information and at the same time these views serve as interaction components to set which information is shown.

Figure 2. TiDi Browser on mobile device – The user interface of TiDi Browser comprises detail view, information view, and thumbnail view. Two time lines visualize photo distance and photo frequency, respectively. Both time lines serve as UI components to navigate in time.

Basically, TiDi Browser is composed of several interactive components which have different tasks and functionality. As common in most photo browsers, TiDi Browser also provides a detail view, an information view, and a thumbnail view (cf. Figure 2). In TiDi Browser, the detail view uses most of the display space, since it is responsible for presenting a selected photo in high resolution. In order to utilize the full display size, it is also possible to maximize the detail view on demand (by tapping on the photo). Meta information about the selected photo (e.g. original photo size, file name, or time and location of the photo shot) is presented in textual form in the information view. The presented text fields are also useful for enabling users to annotate or categorize their photos.

The thumbnail view provides a list of thumbnails that are ordered by the time the photos were taken. The center of the thumbnail view always shows the thumbnail of the currently selected photo. Depending on the available display space, a number of additional thumbnails can be used to depict the temporal context in which the currently selected photo was taken. The thumbnails can be tapped to bring them to the detail view. Furthermore, it is possible to navigate in time by horizontally dragging the thumbnail view. However, this allows only small navigation steps. Components are required which enable a more global navigation, i.e. to switch to distant points in time.

The novelties of the TiDi Browser are its interactive photo frequency chart (depicting the number of photos per date) and photo distance chart (depicting the average distance of the photos taken per date). On the one hand, these charts illustrate the personal photo-taking behavior by visually representing photo frequency and photo distance information (cf. Figure 2). On the other hand, both charts can be used to directly navigate the photo library with respect to time in a more global way.

The basic idea for both charts is to provide interactive time lines for exploring a photo library. With respect to these time lines the mentioned frequency and distances information can be displayed. Specifically, the photo frequency chart visualizes the number of photos taken per date. This enables users to interactively navigate to personally relevant events indicated by dates at which lots of photos were taken. As indicated in the previous section, vacations or more instant happenings can be found easily.

To account for the upcoming availability of location information in digital photos, the second chart is used to illustrate the spatial context in relation to the time line. Due to the limited display space we cannot adhere to approaches where location information is represented via maps. Instead, we try to cope with this limitation by mapping two-dimensional location information to one-dimensional information that can be easily visualized in a chart. This is achieved by considering the distance, rather than the exact location of photos. In other words, not the actual location information is visualized, but the distance between the location of the photo shot and the particular user's home base. This distance (termed photo distance) can be easily calculated using the longitude and latitude coordinates of a photo tagged with GPS information and the respective coordinates of the user's home base. If the mobile device the TiDi Browser runs on is equipped with a GPS receiver, it is alternatively possible to calculate the distance with respect to the current location of the user. The calculated distance is accumulated to a daily average photo distance which in turn is presented in the photo distance chart (average distance per date). As such, this chart provides information about on which dates the user took photos at locations far away from the home base (or the current location). Again, the photo distance chart can be used to directly navigate in time (e.g. navigate to dates where higher distances indicate an overseas vacation). Usually, there exists a dependency between the number of photos taken as represented in the photo frequency chart and the distance between the photo shots and the user's home base as represented in the photo distance chart. Namely, a higher distance for certain dates (e.g. a vacation) will likely imply a larger number of photos on these days. This means that users could identify personal events in both charts. For this reason and to make more display space available for the other components of the TiDi Browser, it makes sense to allow users to fold away either chart on demand.

Since the provided charts can be used to navigate arbitrarily in time (e.g. from one relevant event to the other), the thumbnail view must be update to reflect the new temporal context. Whereas common photo browsers perform an instant switch to the newly selected photo, we implemented the thumbnail view such that it animates the navigation. When navigating from the currently selected photo to a distant event, the thumbnail view starts a scrolling animation leaving the current temporal context. Then the animation speeds up to accelerate the navigation to the newly selected photo. When approaching the selected destination in time the animation slows down to enable users to recognize the new temporal context. Such an animation is especially useful when navigating between distant steps in time. In this case, the animation gives users a visual cue on how far they have navigated in time. This would not be possible with instant switches between time points.

In order to clarify the user interface of the TiDi Browser, Figure 2 depicts its basic components. The figure shows the detail view and the information view as central parts of the user interface. Less display space is dedicated to the thumbnail view, which is below the information view. On either side of the display, the described charts provide temporal overviews of the photo library with respect to photo frequency and photo distance. In both charts, the date of the currently selected photo is indicated by a red bar. Dragging or tapping either chart can be used navigate freely in time, more precisely, to the first photo of the chosen date. This automatically triggers the animated scrolling in the thumbnail view. It is also possible to zoom into a chart on demand to get more detailed views of the photo frequency and photo distance distributions.

3.3. Architectural Issues

Although TiDi Browser uses the limited display space of mobile devices efficiently and is adapted to their different interaction capabilities, the use of the TiDi Browser as a stand-alone application for mobile devices is arguable. It is unlikely that a photo library is located on a mobile device due to the limited disk space. In real world scenarios, users will take pictures and store them on their personal computer or on an Internet server. The latter option is particularly useful to share photos with other users. Moreover, it is impractical to store or handle large photos (1600×1200 pixels and larger) on a mobile device, because this might exceed computational capabilities and storage capacity. Therefore, a client-server-architecture has been developed that addresses the real world

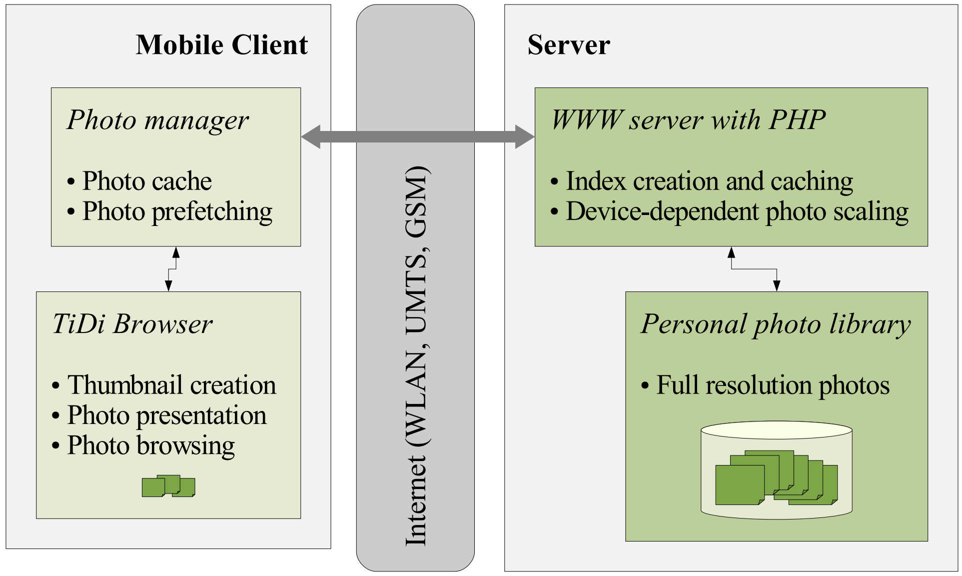

Figure 3. TiDi Browser client-server-architecture – On the client, TiDi Browser requests photos from a component called photo manger. The photo manager is responsible for the communication between the mobile device and the server. A WWW server with PHP provides access to the personal photo library located on the server.

scenario and the limitations of mobile devices. The architecture presented next allows an efficient application of TiDi Browser.

Figure 3 depicts the separation of the developed architecture into parts running on a central server and parts being located on a mobile client. We assume that the users' full resolution images are stored on the server; there are no photos on the mobile device. Therefore, it is necessary to transfer the graphical content from the server to the mobile client. To accomplish this task, we rely on common Internet technology. In particular, we use a WWW server and PHP on the server side. On the client, the photo manager is responsible to send appropriate requests to the server. Before transferring any photos, the photo manager requests from the server a photo index with all necessary meta data. To avoid rescanning all photos in the library over and over again, the meta data is cached and incrementally updated once new photos are added. The photo manager prepares the received meta data for displaying the described charts as well as the information view. Based on the received photo index, the photo manager starts requesting appropriately scaled photos from the server. This means that the server scales high resolution photos from the photo library according to the mobile device's display capabilities. Scaling the photos with respect to the display capabilities of the mobile device is essential in order to reduce the required transmission efforts. It is worth noting that there is no additional transmission of images of different size (e.g. for the detail view or the thumbnail view). Instead, images smaller than the display size (e.g. the thumbnails) are directly scaled by the TiDi Browser. This is possible since the efforts required for further scaling the transferred photos are rather low.[14] If TiDi Browser requests a photo that has not yet been transmitted, the photo manager will load it from the server and fetch it to TiDi Browser in an asynchronous fashion. By this it is ensured that the user interface remains responsive at all times. To keep memory consumption and browsing performance in a sufficient balance, we rely on prefetching and caching. The prefetching strategy tries to utilize idle time to load photos that are close (in terms of time) to the photo currently displayed in the detail view. A certain amount of photos can also be cached to avoid retransmission from the server. Apparently, the size of the photo cache depends on the particular device.

We have implemented a prototype of the previously describe architecture. On the client, we use the .Net Compact Framework; on the server an Apache server with PHP5 was used. We tested our prototype with a photo library of over 900 photos. It must be mentioned that a key to applicability of our methods is a powerful server (to scale photos) and a sufficient Internet connection (preferably WLAN or UMTS).

4. CONCLUSION

In this paper, we presented preliminary results of our research on a novel approach to browsing personal photo libraries on mobile devices called TiDi Browser. We described that photo frequency and photo distance can provide users with potentially interesting and useful insights about their taken photos. The visual representation of this information allows an easy identification of personal events like for instance vacations (greater number of photos and larger distance to the home base), and thus, enables an intuitive navigation to interesting photos. We described a client-server architecture that allows browsing the personal photo library on mobile devices (assumed an Internet connection via WLAN, UTMS, or GSM is available).

In the future, we will further investigate the topic of photo browsing based on time and distances. Obviously, questions regarding scalability (e.g. country vs. state vs. continent vs. world) and granularity (e.g. hour vs. day vs. month) of the presented information must be answered in the future. Moreover, the described charts are based on time lines. It could also be useful to provide a chart that is based on a distance line, i.e. a chart that depicts certain information with respect to the photo distance. Although this would probably not facilitate the identification of personal events, it would enable users to navigate their photo library directly regarding distance. We also think that enabling a combined navigation based on a time line and on a distance line could be very useful. By this it would be possible to first select a distance range (e.g. all photos that have been taken at location with a distance of 100-500 km) and secondly to filter photos taken in a time interval of interest (e.g. the last three months).

Furthermore, we consider providing related semantic information automatically derived from the location of the presented photo (e.g. name or history of buildings near by). We also pursue an automatic clustering of photos to support a later labeling of photos.

The visual interface of the prototype could be improved by integrating focus+context approaches to support the navigation of large photo libraries. Viewing larger photos could be facilitated by utilizing advanced techniques like presented by Rosenbaum and Schumann.[15] Furthermore, the new capabilities of JPEG2000 should be exploited to reduce the efforts required for the image transmission between server and mobile client.

With upcoming technologies like miniaturized autonomous cameras, efficient and intuitive photo browsing techniques will become increasingly important in the future.

ACKNOWLEDGMENTS

We would like to thank all people who have contributed to the work presented here. In particular, we thank Bastian Kirchner from Fraunhofer Institute in Rostock for his support.

REFERENCES

1. K. Rodden and K. R. Wood, “How do people manage their digital photographs?,” in *Proceedings of SIGCHI Conference on Human Factors in Computing Systems*, 2003.
2. H. Kang and B. Shneiderman, “Visualization Methods for Personal Photo Collections Browsing and Searching in the PhotoFinder,” in *Proceedings of IEEE International Conference on Multimedia and Expo*, 2000.
3. B. Bederson, “PhotoMesa: A Zoomable Image Browser Using Quantum Treemaps and Bubblemaps,” in *Proceedings of ACM Symposium on User Interface Software and Technology*, 2001.
4. K. Thys, R. Thys, K. Luyten, and K. Coninx, “PhotoFOAF: A Community Building Service driven by Socially-Aware Mobile Imaging,” in *Proceedings of International Workshop on Semantic Media Adaptation and Personalization*, 2006.
5. A. Graham, H. Garcia-Molina, A. Paepcke, and T. Winograd, “Time as Essence for Photo Browsing through Personal Digital Libraries,” in *Proceedings of Joint ACM/IEEE Conference on Digital Libraries*, 2002.
6. T. T. Computer, “Robogeo.” http://www.robogeo.com.
7. K. Toyama, R. Logan, and A. Roseway, “Geographic Location Tags on Digital Images,” in *Proceedings of ACM International Conference on Multimedia*, 2003.
8. A. Aris, J. Gemmell, and R. Lueder, “Exploiting Location and Time for Photo Search and Storytelling in MyLifeBits,” Tech. Rep. MSR-TR-2004-102, Microsoft Research, 2004.

9. M. Naaman, A. Paepcke, and H. Garcia-Molina, “From Where to What: Metadata Sharing for Digital Photographs with Geographic Coordinates,” in *Proceedings of International Conference on Cooperative Information Systems*, 2003.
10. M. Naaman, Y. Song, A. Paepcke, and H. Garcia-Molina, “Automatic Organization for Digital Photographs with Geographic Coordinates,” in *Proceedings of Joint ACM/IEEE Conference on Digital Libraries*, 2004.
11. S. Harada, M. Naaman, Y. Song, Q. Wang, and A. Paepcke, “Lost in Memories: Interacting With Photo Collections On PDAs,” in *Proceedings of Joint ACM/IEEE Conference on Digital Libraries*, 2004.
12. C. Gurrin, G. Jones, H. Lee, N. O’Harel, A. Smeaton, and N. Murphy, “Mobile Access to Personal Digital Photograph Archives,” in *Proceedings of International Conference on Human Computer Interaction with Mobile Devices & Services*, 2005.
13. B. Shneiderman, “Direct Manipulation: A Step Beyond Programming Languages,” *IEEE Transactions on Computers* **16**(8), 1983.
14. R. Rosenbaum, H. Schumann, and C. Tominski, “Presenting Large Graphical Contents on Mobile Devices - Performance Issues,” in *Proceedings of IRMA International Conference*, 2004.
15. R. Rosenbaum and H. Schumann, “Grid-based Interaction for Effective Image Browsing on Mobile Devices,” in *Proceedings of SPIE Electronic Imaging*, 2005.