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Information Presentation on Mobile Handhelds

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ABSTRACT

Handhelds have become more popular in recent years, and are increasingly used in different application domains. Because of the limited resources of these devices new paradigms for information presentation and interaction facilities are needed.

This paper describes, how innovative methods from the field of information visualization can be used for mobile pocket-sized devices. We focus on special presentation techniques and the visualization of hierarchies for navigation. Moreover, we introduce an effective technique for browsing the World Wide Web via mobile handhelds.

1. INTRODUCTION

Small mobile devices have become more powerful and popular in recent years, and are used in different application areas. However, in future, the wireless and mobile access of data and information via little handhelds will become as popular as browsing the World Wide Web. Since mobile handhelds suffer from limited resources, like screen space, interaction facilities and computational power, new paradigms for information presentation and navigation are needed.

On the other hand, in recent years the visualization of information has evolved to an important and innovative area in computer graphics. It can be described as the use of advanced graphic technologies to present abstract data visually. This includes the process of transforming abstract data into a visual form exploiting the human strengths in rapid visual pattern recognition. A variety of novel visualization approaches and frameworks have been developed and proposed, where 3 main aspects are targeted:

- Visualizing the structure of huge information sets to support navigation and orientation and to show relationships;
- Visualizing the information objects given in a information set, e.g. to support their identification, or to layout them according to similarities, and
- Visualizing the data values, which describe information objects.

Nevertheless, these approaches were designed for stationary devices, and using them for mobile handhelds leads to unsolved problems. Since the screen space of mobile handhelds is very limited, we can present relatively small parts of information content only. To avoid extensive scrolling and panning, relationships between information objects are shown. A number of customized methods to visualize the information structure have been developed. Especially, hierarchical methods are well capable for mobile handhelds, since the number of presented nodes (or information, generally spoken) can be controlled effectively. Nevertheless, it could be difficult to show all nodes on limited display sizes. To use the screen space efficiently and to increase the amount of visualized information, specialized presentation techniques have been proposed. So called FOCUS & CONTEXT techniques are a popular example of this approach (e.g. [LeA 94], [Kea 98]).

This paper focuses on information presentation on pocket-sized devices. In section 2 we show how special presentation techniques from the field of information visualization can be applied to display large images on small devices. In section 3 we present two examples to visualize hierarchies on mobile handhelds, e.g. for navigation and orientation purposes. Furthermore, we propose an approach for browsing the Web via mobile devices (section 4). Future work and conclusions closing our contribution in section 5.

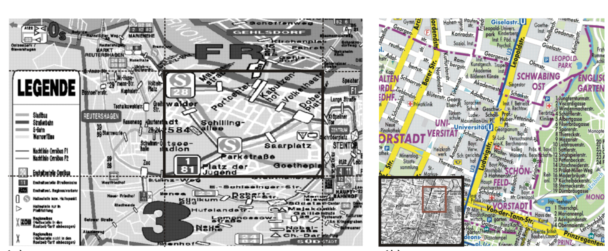
2. PRESENTATION TECHNIQUES TO DISPLAY LARGE IMAGES ON MOBILE HANDHELDS

In mobile environments, the size of large images often exceeds the display area of the users output device. In this section, we want to describe how presentation techniques from information visualization can be used to solve this problem.

The basis of every presentation technique is the transformation of the image from logical to display coordinates. The transformation function depends on the used presentation technique and the available display space. The 2D-logical coordinate system contains the undistorted pixel representation of the image to display. These image data is mapped into a 2D-display coordinate system, which represents the available display area of the mobile device.

The way often used to overcome the limitation of screen size is to pan the undistorted image depending on the viewers current interests. In this case, the transformation function simply consists in a pixel mapping. If Panning is used exclusively, the user has no information about other areas of the image until he pans to these regions. After he left his current view all information about this position is discarded, which demands a viewers complete attention. Sometimes this technique is combined with Zooming. Here, depending on the zoom factor, the transformation function has to scale the content to the available display space. Zooming and Panning are easy to implement and need only low processing power.

One technique which can be used in mobile devices to combine the display of image details with context information is the RECTANGULAR FISHEYE-VIEW [RJS 01]. This view belongs to the class of FOCUS & CONTEXT techniques, which embed the detailed information directly into the context. To be able to display large parts of the image as context information, they have to be distorted. The RECTANGULAR FISHEYE-VIEW applies



1a) Rectangular FishEye-View 1b) Large Focus-Display

Figure 1: Two examples to display images on small devices

different distortions to different parts of the image starting with less distortion near the focus to strong distortion near the borders of the available display size (Fig. 1a). Based on [RJS 01], we suggest different implementations of the transformation function with respect to the distortion of the context.

By using *uniform scaling,* the complete image in the logical coordinate system is divided into a focus and a surrounding context belt. To map the context on the display coordinate system, the context belt is divided into non-overlapping areas, where to each of them a uniform scaling is applied. The uniform scaling is a straightforward and computationally inexpensive. A disadvantage is aroused by the scaling, which causes an visible discontinuity on the transitions to other areas.

Another more complex implementation is the *belt-based scaling,* where more than one context belt is used to allow a more adapted scaling of the content. Every belt is created in the same way as in uniform scaling, apart from the fact that belts near the focus are less scaled than belts on the displays borders. The use of more than one belt leads to decreased visual discontinuities, but they can not be fully removed. Furthermore, it needs more computational power than the uniform scaling, what can not be neglected for mobile devices. In *non-uniform scaling,* the requirement of a smooth transition from the focus to the context can be achieved. As in the uniform case – a single context belt is used. Unlike the former case, the context scaling factor is continually increasing with increasing distance from the focus. This method leads to the best visual results, but can be inapplicable to mobile devices with very limited processing power.

The focus area itself is created by a simple pixel mapping. The focus obtains its size and relative position in both coordinate systems, which makes it rather easy to navigate within the image. The FISHEYE-VIEW in general can be applied to display raster and vector images similarly.

In many applications the user is rather interested in a specific detail than in the context. Beside the RECTANGULAR FISHEYE-VIEW, we want to introduce an adapted FOCUS & CONTEXT – technique, the LARGE FOCUS-DISPLAY (Fig. 1b), which uses a different strategy to combine focus and context without to change the distortion within the context. Here, most of the available space is used to view the focus and only a small part represents context. The context is a downscaled version of the image, where the currently displayed focus region is drawn in. This allows a panning-like appearance in combination with an additional view of the whole content and compensates most of the disadvantages of ordinary panning. Nevertheless, the content region hides some of the focus area. To overcome this, the placement of the content rectangle can be chosen interactively, which allows the complete view of the focus region. The transformation function is quite similar to Panning and Zooming, which makes it rather fast during interaction. Therefore, it is useful especially for palm-size devices. The focus area is created as during Panning, except the area which is occupied by the context. This area contains a downscaled version of the whole image in the logical coordinate system, which is mapped, as during zooming, to a smaller area in the display coordinate system.

All of the proposed techniques show a new way to display large images on small mobile devices by using already existing concepts in information visualization.

3. VISUALIZATION OF HIERARCHIES ON MOBILE HANDHELDS

Due to the limited screen space of mobile handhelds, we can only present small parts of the whole information at once. Therefore, we need a special treatment, to connect this parts, and to support navigation and orientation. One way in doing so, is the visualization of the relationships between information objects representing parts of information content.

This structure can be expressed as graph, whereas the nodes present the information objects, and the edges the relations between them. Several graph drawing methods have been proposed [dBa 99]. However, it can be difficult to keep the orientation, if we can not assure, that all nodes are drawn. On the other hand, hierarchical structures allow an efficient control of the number of nodes to be presented. Many information structures are hierarchical, e.g. file systems. Moreover, graphs can be decomposed other hierarchical structures [AbK 00]. Therefore, hierarchical methods can be applied to show information structures on mobile handhelds. A number of customized methods to visualize hierarchical structures have been developed (e.g. [RMC 99], [Shn 92], [StZ 00], [Lam+ 95]). We use the MAGIC EYE VIEW [KLS 00] for our purposes.

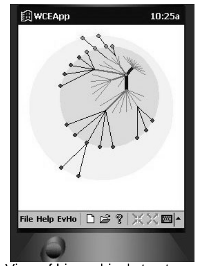


Figure 2: Magic Eye View of hierarchical structures on mobile handhelds

The MAGIC EYE VIEW is based on a 2D radial layout, which is mapped onto a hemisphere. The hierarchy levels on the hemisphere are color-coded to separate the levels. An additional projection is introduced in order to achieve a FOCUS & CONTEXT display and to enable a smooth transmission between these regions. The center of the projection is the midpoint of the hemisphere and rays from the center point to each node on the hemisphere are created. By retaining the direction of these rays and changing the center of projection we get new node positions by the ray's intersection points with the hemisphere. Thus, the distances between nodes are different depending on the position of the projection center. The increased region provides more space to view details and can be considered as focus region.

Since interactive 3D FOCUS & CONTEXT visualization exceeds the capabilities of handhelds we have to introduce new mechanisms for adaptation and reduction of these techniques.

We apply two concepts:

- Reduction of graphical presentation, and
- Reduction of the information set.

To reduce the complexity of graphical output we use a 2D representation. This also includes the application of elementary graphical primitives like circles, triangles and lines instead of 3D primitives and curves.

To reduce the complexity of the structure to be presented we use a special interaction technique, called EVENT HORIZON [Tai 99]. The key idea of this concept is the compression and expansion of graphical representation by a radial movement of objects, which aligns every object with a certain distance to the event horizon in the middle of the screen. The event horizon can be considered as a graphical abstraction of a certain set of nodes according to the user's interaction. If the set of nodes in the event horizon is large, we can explore nodes on high levels of the hierarchy, and vice versa.

For effective exploration of hierarchical structures using this approach, it is necessary to provide an overview for the number of nodes in the event horizon. Here, we use a small circle to represent the event horizon. This circle can be drawn in 3 different styles:

- **Minigraph**
  The structure in the event horizon is abstracted by an iconographic view, whereas little edges are displayed only.
- **Circlets**
  The circle is represented by little circlets according to the visible number of levels.
- **Symbol**
  On the midpoint of the circle a further little circle is drawn and color coded regarding the visible number of nodes.

It is obvious, that information is lost, and space requirements decrease from the first to the third variant.

Beside the discussed concept of event horizon, we use the approach of folding and unfolding subtrees [HMD 98] to reduce the complexity of hierarchical structures. To achieve this, the user can select one node in the structure, and nodes of the belonging subtree will be hidden. Additionally, the folded node is marked. Clicking a folded node causes an enfolding, which means a display of the belonging subtree.

4. BROWSING THE WORLD WIDE WEB WITH MOBILE HANDHELDS

In this section we present a special application for representation of Web contents on mobile handhelds. In particular, it covers the adaptation of web pages, which have not been sketched for such devices. This requires a special treatment to ensure the information of the whole Web can be used.

There are several approaches for the adaptation of web pages:

- Device based adaptation
  For different types of devices special web pages are available. Examples are web pages made with WML. One advantage is the optimal usage of device dependent properties. A drawback is the little availability of such pages.
- Layout based adaptation
  Here, different layout classes are defined based on criteria like degree of abstraction. These classes can be applied to web pages. For example, layouts can be specified for different output media by using cascading style sheets (CSS). However, it needs a special preparation of the pages.
- Client based adaptation
  This approach uses the original information and changes the presentation on the output device only. Appropriate adaptation can be done by applying special algorithms or rules. Some examples that use Focus & Context (Flip Zooming [BHR+99], CZWeb [FAD+97]) or overview & detail (Power Browser [BMP+00], WebThumb [WFH+02]) are well-known. The necessary information must be fast generable from the original document.
- Document based adaptation
  Any web page is transformed with their presentation on the display in mind. It is possible to change the structure or content of elements of a web page. Examples are section outlining (Zippers [BrW 96]), removal or scaling of pictures (Power Browser), or text filtering and generation of a summary (West [BHR+99]).

To present Web pages on mobile handhelds, we have developed a client based adaptation in connection with techniques from the document based adaptation. Therefore, we allow the accessibility of all information and use the same presentation as on PC-oriented HTML sites as far as possible. We restrict ourselves on documents containing HTML elements especially used in scientific articles.

The base of the technology is a data structure called Webgraph. This tree records the layout of a web page. Leaf nodes represent single web elements like text, illustration, link, and headings. Interior nodes are frames, tables, table contents and paragraphs. Furthermore, a set of possible edges must be defined to specify the relationships between nodes.

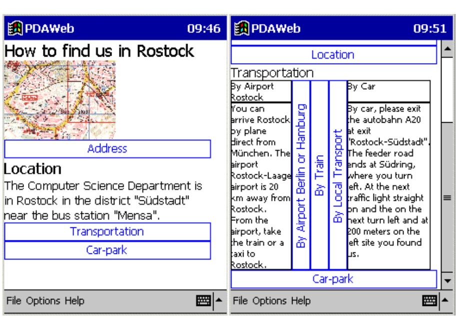


Figure 3: Examples on Section Folding

An example are the edges of a paragraph node. Children of a paragraph could be paragraph nodes, tables, text, illustrations, links, headings and branches. That means, possible edges from a paragraph are edges to one ore more of those elements. For a clear specification of the Web document some further definitions and rules must be made.

Based on the Webgraph, three concepts (Section Folding, Relative Size and Keyword Overview) have been developed to present HTML documents.

We introduced Section Folding as enhancement of section outlining, which replaces textual parts of a document by hyperlinks. Section folding operates on the Webgraph, so every node or subgraph can be replaced or hidden. Because there are several classes of nodes, it is possible to process them differently to achieve an efficient treatment. For example, to generate the textual information for hypertext, we can use a name in a table node or the first sentence in a text node. In order to use section folding optimally, an automatic computation of the starting situation is necessary. For information filtering on a tree, the Filter-FishEye-View[Fur81] can be applied. A degree of interest is determined starting from the current point of interest with a distance function and a certain level of detail. Uninteresting information can be hidden by a threshold value.

With Relative Size the extent of elements within a web page is adapted to the display of a mobile device, so it is possible to handle node types like text, structural components and illustrations differently. Textual elements use fonts and font size of the handhelds. The size for structural components can be processed by absolute size, by the relative size compared to parent- or sister nodes or as a collection of child nodes. Images can be displayed in its original size, scaled or with an implementation of the Rectangular FishEye-View (see section 2).

The approach Keyword Overview uses techniques from text filtering for the fast navigation on web sites. Keywords are listed in an additional window, so it is possible to jump to the appropriate regions within the presentation window.

Figure 3 shows an example of a scaled and folded Web site. In the left window one paragraph is unfolded. The other window shows three columns in the center of a table which have been folded and replaced by info-bars.

5. CONCLUSIONS

Information presentation on mobile handhelds requires a special treatment to consider the limited resources of these devices like screen space, interaction facilities and computational power. Nevertheless, basic techniques from the field of information visualization can be adapted to these purposes.

In this paper we have introduced presentation techniques to optimize the display of large images on small screens. Furthermore, we proposed a technique to visualize hierarchical structures on mobile devices. Therefore, we adapted the Magic Eye View, and integrated the interaction paradigm Event horizon. Lastly, we have discussed concepts for browsing the Web via handhelds.

All these examples showed the feasibility of information presentation on handhelds. Further work will concentrate on the combination of the proposed approaches in a general framework and usability tests. Moreover, we want to adapt and integrate more techniques like graph drawing algorithms, and evaluate our work by several application cases.

6. ACKNOWLEDGMENT

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