Navigation Patterns and Usability of Zoomable User Interfaces with and without an Overview

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The literature on information visualization establishes the usability of interfaces with an overview of the information space, but for zoomable user interfaces, results are mixed. We compare zoomable user interfaces with and without an overview to understand the navigation patterns and usability of these interfaces. Thirty-two subjects solved navigation and browsing tasks on two maps. We found no difference between interfaces in subjects' ability to solve tasks correctly. Eighty percent of the subjects preferred the interface with an overview, stating that it supported navigation and helped keep track of their position on the map. However, subjects were faster with the interface without an overview when using one of the two maps. We conjecture that this difference was due to the organization of that map in multiple levels, which rendered the overview unnecessary by providing richer navigation cues through semantic zooming. The combination of that map and the interface without an overview also improved subjects' recall of objects on the map. Subjects who switched between the overview and the detail windows used more time, suggesting that integration of overview and detail windows adds complexity and requires additional mental and motor effort.

Categories and Subject Descriptors: H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*evaluation/methodology; interaction styles (e.g., commands, menus, forms, direct manipulation)*; I.3.6 [**Computer Graphics**]: Methodology and Techniques—*interaction techniques*

General Terms: Experimentation, Human Factors, Measurement, Performance

Additional Key Words and Phrases: Information visualization, zoomable user interfaces (ZUIs), overviews, overview+detail interfaces, navigation, usability, maps, levels of detail

1. INTRODUCTION

Information visualization [Card et al. 1999] has become a successful paradigm for human-computer interaction. Numerous interface techniques have been

This work was funded in part by DARPA's Command Post of the Future project, contract number F336159711018, and ChevronTexaco.
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proposed and an increasing number of empirical studies describe the benefits and problems of information visualization, for example, Beard and Walker [1990], Schaffer et al. [1996], Hornbæk and Frøkjær [1999], Chen and Czerwinski [2000]. Interfaces with an overview and zoomable user interfaces have been extensively discussed in the literature on information visualization. Interfaces with an overview, often called *overview+detail interfaces* [Plaisant et al. 1995], show the details of an information space together with an overview of the entire information space. Such interfaces can improve subjective satisfaction (e.g., North and Shneiderman [2000]), and efficiency (e.g., Beard and Walker [1990]). Zoomable user interfaces organize information in space and scale, and use panning and zooming as their main interaction techniques [Perlin and Fox 1993; Bederson et al. 1996]. Research prototypes of zoomable user interfaces include interfaces for storytelling [Druin et al. 1997], Web browsing [Hightower et al. 1998], and browsing of images [Combs and Bederson 1999; Bederson 2001]. However, few empirical studies have investigated the usability of zoomable user interfaces, and the results of those studies have been inconclusive. In addition, the usability of overviews for zoomable user interfaces has not been studied.

In this article we present an empirical analysis of zoomable user interfaces with and without an overview. We investigate the following:

—how the presence or absence of an overview affects usability;
—how an overview influences the way users navigate information spaces; and
—how different organizations of information spaces may influence navigation patterns and usability.

With this work, we aim to strengthen the empirical literature on zoomable user interfaces, thereby identifying challenges for researchers and advising designers of user interfaces.

In Section 2, we review the literature on overviews and zoomable user interfaces. Then, we present our empirical investigation of differences in navigation patterns and usability in zoomable user interfaces with and without an overview. Finally, we discuss the trade-off between time and satisfaction in such interfaces and explain the interaction between usability and differently organized information spaces.

2. RELATED WORK

This section summarizes the research questions and empirical findings about interfaces with overviews and zoomable user interfaces. It explains the literature behind our design decisions and the motivation for the experiment, both described in subsequent sections.

2.1 Interfaces with Overviews

Interfaces with overviews present multiple views of an information space where some views show detailed information about the information space (called *detail windows*), while other views show an overview of the information space (called *overview windows* or *overviews*). Examples of such interfaces include editors

for program code [Eick et al. 1992], interfaces for image collections [North et al. 1995], and commercial programs such as Adobe Photoshop.[1] Interfaces with an overview have been found to have three benefits. First, navigation is more efficient because users may navigate using the overview window rather than using the detail window [Beard and Walker 1990]. Second, the overview window aids users in keeping track of their current position in the information space [Plaisant et al. 1995]. The overview window itself might also give users task-relevant information, for example, by enabling users to read section titles from an overview of a document [Hornbæk and Frøkjær 2001]. Third, the overview gives users a feeling of control [Shneiderman 1998]. A drawback of interfaces with an overview is that the spatially indirect relation between overview and detail windows might strain memory and increase the time used for visual search [Card et al. 1999, p. 307]. In addition, such interfaces require more screen space than interfaces without overviews.

Taxonomies and design guidelines for overviews [Beard and Walker 1990; Plaisant et al. 1995; Carr et al. 1998; Baldonado et al. 2000] contain three main points. First, the overview and detail windows need to be tightly coupled [Ahlberg and Shneiderman 1994], so that navigation or selection of information objects in one window is immediately reflected in the other windows. Tight coupling of overview and detail views has been found useful in several studies (e.g., North and Shneiderman [2000]). Second, for any relation between overview and detail windows, the zoom factor is the ratio between the larger and smaller of the magnification of the two windows. For overview+detail interfaces, this factor is recommended to be below 25 [Plaisant et al. 1995] or below 30 [Shneiderman 1998]. It is unclear, however, if the sizes of the detail and overview windows influence the recommended zoom factor. Third, the size of the overview window influences how much information can be seen at the overview and how easy it is to navigate on the overview. However, a large overview window might take screen real estate from the detail window. Plaisant et al. [1995] argued that the most usable sizes of the overview and detail windows are task dependent. A large overview window, for example, is required for a monitoring task, while a diagnostic task might benefit from a large detail window.

A number of empirical studies have found that having an overview improves user satisfaction and efficiency over interfaces without an overview. Beard and Walker [1990] compared the effect of having an overview window to navigating with scrollbars. In a 280-word ordered tree, subjects used an overview window that allowed dragging a field-of-view and one that allowed both dragging and resizing the field-of-view. For tasks where subjects tried to locate a word in the tree and tasks where they repeatedly went from one side of the tree to the other, the overview window led to significantly faster task completion. North and Shneiderman [2000] compared 18 subjects' performance with a detail-only, an uncoordinated overview+detail, and a coordinated overview+detail interface for browsing textual population data. Compared to the detail-only interface, the coordinated interface was 30–80% faster and scored significantly higher on a satisfaction questionnaire. Hornbæk and Frøkjær [2001] compared an interface

[1]See http://www.adobe.com/photoshop/.

with an overview for electronic documents to a fisheye and a detail-only interface. Essays produced with aid of the interface with an overview scored significantly higher than essays produced with the detail-only interface. However, for tasks that required subjects to answer a specific question, the interface with an overview was 20% slower compared to the detail-only interface. All but one of the 21 subjects preferred having the overview.

2.2 Zoomable User Interfaces

While zoomable user interfaces have been discussed since at least 1993 [Perlin and Fox 1993], no definition of zoomable user interface has been generally agreed upon. In this article, we consider the two main characteristics of zoomable user interfaces to be (a) that information objects are organized in space and scale, and (b) that users interact directly with the information space, mainly through panning and zooming. In zoomable user interfaces, space and scale are the fundamental means of organizing information [Perlin and Fox 1993; Furnas and Bederson 1995]. The appearances of information objects are based on the scale at which they are shown. Most common is geometric zoom, where the scale linearly determines the apparent size of the object. Objects may also have a more complex relation between appearance and scale, as in so-called semantic zooming [Perlin and Fox 1993; Frank and Timpf 1994], which is supported in the zoomable user interface toolkit Jazz [Bederson et al. 2000]. Semantic zooming is commonly used with maps, where the same area on the map might be shown with different features and amounts of detail depending on the scale. Constant density zooming [Woodruff et al. 1998a] introduces a more complex relation between scale and appearance where the number of objects currently shown controls the appearance of objects, so that only a constant number of objects is visible simultaneously.

The second main characteristic of zoomable user interfaces is that the information space is directly visible and manipulable through panning and zooming. Panning changes the area of the information space that is visible, and zooming changes the scale at which the information space is viewed. Usually, panning and zooming are controlled with the mouse or the keyboard, so that a change in the input device is linearly related to how much is panned or zoomed. Nonlinear panning and zooming have been proposed in three forms: (a) goal-directed zoom, where direct zooming to an appropriate scale is supported [Woodruff et al. 1998b]; (b) combined zooming and panning, where extensive panning automatically leads to zooming [Igarishi and Hinckley 2000]; and (c) automatic zoom to objects, where a click with the mouse on a object automatically zooms to center on that object [Furnas and Zhang 1998; Ware 2000]. When zooming, two ways of changing scale are commonly used. In jump zooming, the change in scale occurs instantly, without a smooth transition. Jump zooming is used in Pad [Perlin and Fox 1993], Schaffer et al.'s [1996] experimental system, and commercial systems such as Adobe PhotoShop or MapQuest.[2] In animated zooming the transition from the old to the new scale is smooth [Bederson and Hollan 1994; Pook et al. 2000; Bederson et al. 2000]. An important issue in animated zooming is the

[2]See http://www.mapquest.com/.

duration of the transition and the user's control over the zooming speed, that is, the ratio between the zooming time and the zooming factor. Guo et al. [2000] provided preliminary evidence that a zoom speed around 8 factors/s is optimal. Card et al. [1991] argued that the zoom time should be approximately 1 s, although in some zoomable user interfaces, for example, Jazz, users can control both the zoom time and the zoom factor. Bederson and Boltman [1999] investigated whether an animated or jump zoom technique affected 20 subjects' ability to remember the topology of and answer questions about a nine-item family tree. Subjects were better at reconstructing the topology of the tree using animated zooming, but no difference in satisfaction or task completion time was found.

The empirical investigations of zoomable user interfaces are few and inconclusive. Páez et al. [1996] compared a zoomable user interface based on Pad++ [Bederson and Hollan 1994] to a hypertext interface. Both interfaces gave access to a 9-page scientific paper. In the zoomable user interface, the scale of the sections and subsections of the paper were manipulated, so that the entire paper fit on the initial screen. No significant difference was found between the two interfaces for the 36 subjects' satisfaction, memory for the text, or task completion time. Schaffer et al. [1996] compared 20 subjects' performance with a zoomable user interface and a fisheye interface. Subjects had to locate a broken link in a telephone network and reroute the network around the link. Subjects used 58% more time for completing the task in the zoomable user interface. Subjects seemed to prefer the fisheye interface, although this was not clearly described in the paper.

Hightower et al. [1998] presented two experiments that compared the history mechanism in Netscape Navigator with a graphical history in a zoomable user interface called *PadPrints*. In the first experiment, 37 subjects were required to answer questions about Web pages. No significant difference in task completion time was found, but subjects preferred the PadPrints interface. In the second experiment, subjects were required to return to already visited Web pages. Subjects were approximately 40% faster using the PadPrints interface and preferred PadPrints to Netscape Navigator. Combs and Bederson [1999] compared four image browsers: two commercial 3D interfaces, one commercial 2D interface, and an image browser based on Pad++. Thirty subjects searched for images in an image database that they had just browsed. Subjects were significantly faster using the 2D and the zoomable user interfaces, especially as the number of images in the database went from 25 to 225. The study presented some evidence that recall of images is improved in the zoomable user interface, but found no difference in subjective satisfaction between interfaces. Ghosh and Shneiderman [1999] compared 14 subjects' use of an overview+detail and a zoomable user interface to personal histories, LifeLines [Plaisant et al. 1996]. The zoomable user interface was marginally slower than the overview+detail interface. No difference in subjective satisfaction was found.

In general, the experimental results about zoomable user interfaces are mixed, reflecting differences in the interfaces that zoomable user interfaces are compared to, in the organization and size of the information spaces used, and in the implementation of zooming. In addition, the characteristics of zoomable user

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