An Experimental Investigation of Magnification Lens Offset and Its Impact on Imagery Analysis

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ABSTRACT
A digital lens is a user interface mechanism that is a potential solution to information management problems. We investigated the use of digital lensing applied to imagery analysis. Participants completed three different types of tasks (locate, follow, and compare) using a magnification lens with three different degrees of offset (aligned, adjacent, and docked) over a high-resolution aerial photo. Although no lens offset mode was significantly better than another, most participants preferred the adjacent mode for the locate and compare tasks, and the docked mode for the follow tasks. This paper describes the results of a user study of magnification lenses and provides new insights into preferences of and interactions with digital lensing.

CR Categories: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Graphical user interfaces; H.1.2 [Models and Principles]: User/Machine Systems—Human Factors; I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction Techniques

Keywords: Information visualization, imagery analysis, magnification lens, lens interaction, usability study

1 INTRODUCTION

A common challenge in imagery analysis is the ability to zoom-in to obtain details while preserving the necessary context. Current popular techniques to address this problem include pan/zoom and overview windows. We explore another UI mechanism to address the information management problem—digital lensing.

We investigated the use of a magnification lens in three different offset modes—aligned, adjacent, and docked [Figure 1]. The purpose was to determine whether the degree of offset impacted performance when analyzing imagery. What we present are ways to design lenses with intuitive interaction techniques that allow users to better focus on detail while still maintaining an overview.

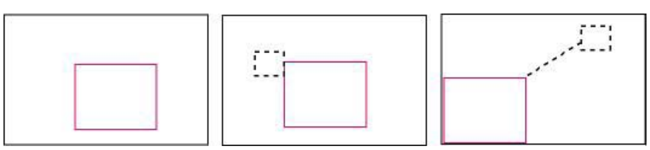

Figure 1. Lens and source windows aligned, lens adjacent to the source window, and lens docked (left to right).

1.1 Related Work

It is well understood [5] that when linear zooming is used to gain detail, context is lost, creating a significant usability problem. Therefore, the majority of research in magnification lenses has focused on fisheye and other distortion techniques to gain detail while preserving the necessary context [2,1,4]. However, Ware and Lewis [7] developed an image magnifier prototype called DragMag that displays a zoomed portion of an image in a window that is offset from the corresponding part of the base image. The amount of offset is sufficient to preserve the context of the zoomed region. Lines are drawn between the zoom window and the region of the base image being magnified to visually indicate the connection between context and detail. Based on evaluation of the prototype, it was concluded that the zoomed windows should be both sizable and movable with respect to the base image. This recommendation was incorporated by Greenberg, Gutwin, and Cockburn into the Offset Lens, a shared workspace awareness tool [3]. They note that while the adjustable amount of offset allows for "simultaneous views of the area of interest in both global and local contexts," a user's attention can become divided between these two areas of context. To solve this attention problem, they allow the visibility of the background and the opacity of the context to be adjusted.

We found minimal evidence of HCI investigations into the use of magnification lenses for the military and this research is an early step in exploring the role that lenses can play in imagery analysis.

2 LENS PROTOTYPE DEVELOPMENT

We developed an application prototype of magnification lenses for imagery analysis tasks. The prototype provides an initial tool and framework to explore various lens types, lens interaction techniques, and related user interface (UI) options. The prototype was implemented in C++ using the OpenGL graphics API.

Our magnification lens is composed of two parts: the *lens* and *source* windows. In the lens window, the user sees the magnified view of the data of interest. The source window corresponds directly to the data of interest; it is a box drawn over the unmagnified data. In aligned mode, the lens window was located directly over the source window. In adjacent mode, the lens window remained directly next to the source window. In docked mode, the lens window remained in the lower left-hand corner of the screen as the source window was dragged around the scene.

3 LENS STUDY

A usability study was conducted to determine how the degree of offset of the lens from the source window impacted performance when analyzing imagery. The independent variables were the degree of offset (aligned, adjacent, docked) and the type of analysis task (locate, follow, compare). The dependent variables were task completion accuracy, task completion time, and user satisfaction ratings. A counterbalanced, within-subjects design was used. Twelve participants were recruited from The MITRE Corporation. Most were familiar, but had minimal experience, with magnification lenses.

Each participant completed a series of five tasks for each of the three lens offset positions (aligned, adjacent, and docked). Of the five tasks, two involved finding a location, two were following a path, and one was comparing two images to identify small differences. After finishing the tasks, each participant completed a questionnaire to rate his or her preference of the different lens offset modes.

3.1 Results

3.1.1 Task Completion Accuracy

Three one-way ANOVAs were conducted to compare the average accuracies between lens modes on each task, and a two-way ANOVA compared all three lenses with each comparison task. Between the follow and locate tasks there was near perfect accuracy (97%) on task completion. The two incorrect answers were on the same follow task using the docked lens, and were due to individuals' varying judgments of distance. However, on the comparison tasks the accuracy varied slightly among the lenses. With an overall 90% accuracy among all lenses for the comparison tasks, the docked lens had the most correct answers at 93% accuracy, while adjacent was the worst at 89%. These differences are not statistically significant, but warrant further studies.

3.1.2 Task Completion Time

Fifteen one-way ANOVAs were conducted to compare the average times between lens modes on each task, a two-way ANOVA compared the average times of each lens mode across tasks, and a two-way ANOVA compared the average times of each lens mode for each type of task separately. While the means for participants' times on each task varied from lens to lens, no single task showed a significant difference. There were no significant main or interaction effects. The docked lens was nearly significantly worse than aligned and adjacent for two of the six locate tasks. In addition, the aligned lens was nearly significantly better than adjacent and docked for the follow tasks.

3.1.3 User Satisfaction

Table 1 shows the number of participants that selected an offset mode as the best for accomplishing a type of task. For locating a specific item, adjacent was chosen by 92% of the participants as the best offset mode. For following a path, 50% of the participants selected docked as the best mode. For comparing two images to identify small discrepancies, 67% of the participants chose adjacent again as the preferred mode.

Table 1. Number (and percentage) of participants that chose a particular offset mode as being the best for completing a type of imagery analysis task.

	Aligned	Adjacent	Docked
locate	1 (8%)	11 (92%)	0 (0%)
follow	4 (33%)	2 (17%)	6 (50%)
compare	1 (8%)	8 (67%)	3 (25%)

Participants then rated for each lens whether they would use it again to inspect an image on a five-point Likert scale (1—strongly disagree to 5—strongly agree). The adjacent lens was rated the highest (mean=4.18, SD=1.08) with the mean score corresponding to an Agree, the next highest was docked (mean=2.45, SD=1.29) with the mean score corresponding to slightly less than Neutral, and then aligned (mean=1.64, SD=.92) with the mean score corresponding to slightly less than Disagree.

The participants drew similar conclusions about the strengths and weaknesses of the offset modes. The advantage of the aligned lens was that it did not force eyes to shift between the two windows. The disadvantage was that the immediate context surrounding the source window was covered by the lens. The strength of the adjacent lens was that it preserved most of the surrounding context of the source window, but the weakness was that it reoriented itself when it approached an edge of the scene. The advantage of the docked was that the user could see the entire context surrounding the source window easily. The disadvantage was that the user needed to look back and forth between the lens and the source, which could be far apart.

4 CONCLUSION

In the sessions, we observed that the magnification lens is an intuitive interaction technique for analyzing imagery as we consistently noticed each participant naturally following the Visual Information Seeking mantra: Overview first, zoom and filter, then details-on-demand [6]. They would scan the high-resolution image looking for any irregularities or specific characteristics and then use the magnification lens to zoom-in to inspect the detailed view.

The statistical analysis resulted in interesting findings (although none significant), such as a docked lens being worse for locating tasks but better for comparison tasks, and an aligned lens being better for follow tasks, that should be explored in future work. Participants almost unanimously rated the adjacent lens as being the preferred offset mode for locate tasks, and the majority preferred it for the compare tasks. Docked was the most preferred mode and adjacent was the least preferred for the follow task. These findings indicate that different degrees of offset of the lens from the source should be offered to imagery analysts.

4.1 Future work

We would like to investigate the use of two lenses for the comparison task, with the two lenses being locked together, resulting in both moving in tandem over the two images being compared. All participants asked for this capability and it would provide greater insight into which of the three offset modes are best for comparison tasks. In addition, we would also like to compare the magnification lens in adjacent offset mode to a fisheye lens because both methods preserve context.

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