Sweeping Away Disorder with the Broom Alignment Tool

Jason Robbins, Michael Kantor, David Redmiles
Information & Computer Science
University of California, Irvine
Irvine, CA 92697 USA
+1 949 824 {7308,2703,3823}
{jrobbins,mkantor,redmiles}@ics.uci.edu

ABSTRACT
Design diagrams play an important role in many disciplines. Many types of diagrams use spacing and alignment to communicate implicit relationships between objects within the diagram. We describe and evaluate a direct manipulation alignment tool based on a push-broom metaphor.

Keywords
Secondary Notation, Design Diagrams, Direct Manipulation

INTRODUCTION
Design diagrams in any given field follow a formal syntax that assigns meaning to specific graphical shapes, connections, and labels. Beyond formal syntax, a set of diagramming conventions exists within each design community. However, there are other visual aspects of diagrams that are left to the designer's discretion. These may include the color, size, location, spacing, and alignment of diagram elements. Designers use these unassigned visual aspects in a "secondary notation" that expresses relationships that are of concern, but that are not covered by the formal notation [3]. In programming, blank lines and indentation communicate structure, grouping, and emphasis. Likewise, in a design diagram, objects can be aligned to show logical structure, grouping, correspondence, or emphasis. Green and Petre point out that visual similarity between two design fragments can define a visual "rhyme" that cue the reader to expect deeper semantic correspondence [3]. In Figure 1, alignment implies grouping and correspondence of steps. Alignment is an important form of secondary notation, and the focus of this paper.

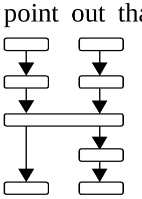
Figure 1

The observation that designers use secondary notation identifies an important usability requirement for design diagram editors. However, the interfaces of most of these tools are inspired by generic drawing tools and do not provide specific support for secondary notation.

In the following sections we address some weaknesses of current alignment tools and how we address them in our broom alignment tool. This paper reports on a study that we conducted to compare the usability of the broom and the standard alignment tools.

Standard Alignment Tools
Most design tools provide some feature to help align diagram elements with each other. These include features to enable users to nudge objects into position, snap-to-grid, snap-to-guidelines, and others. Figure 2 shows a standard set of alignment and spacing commands from Microsoft Office98.

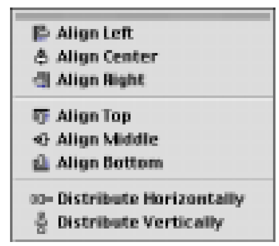

Figure 2

Issuing an alignment command requires users to select a set of objects, choose a command, and evaluate the result. Choosing requires users to compare their mental picture of the desired result to the picture or phrase associated with the command. Also, these commands move objects abruptly, which can hinder visual evaluation. We believe this interaction has a noticeable cognitive load.

We set out to devise an alignment tool with a lower cognitive load that would better suit the needs of our users. Our users are software engineers working with UML (Unified Modeling Language) diagrams [1]. These diagrams frequently have objects in visual groups that are both aligned and evenly spaced. We observed that users can easily bring related objects into rough groups, but had difficulty achieving precise alignment. In the next section we describe the broom alignment tool that combines alignment and distribution into a single, direct manipulation.

The Broom Alignment Tool
Like a real-world push broom, the broom tool pushes objects that come into contact with it. This has the effect of aligning objects along the face of the broom and provides immediate visual feedback (Figure 3).

Unlike a real-world broom, moving backwards allows objects to return to their original position (Figure 4). Moving laterally grows the broom's face, allowing more objects to be aligned. If the user presses the space bar while using the broom, objects on the face of the broom are distributed evenly. Repeatedly pressing the space bar cycles among several distribution styles.

Effort sponsored by the Defense Advanced Research Projects Agency, and Air Force Research Laboratory, Air Force Materiel Command, USAF, under agreement number F30602-97-2-0021 and F30602-94-C-0218, and by the National Science Foundation under Contract Number CCR-9624846. The U.S. Government is authorized to reproduce and distribute reprints for governmental purposes notwithstanding any copyright annotation thereon. The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of the Defense Advanced Research Projects Agency, Air Force Research Laboratory or the U.S. Government.

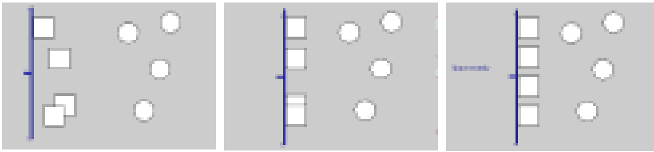

Figure 3. Using the broom to align and space objects.

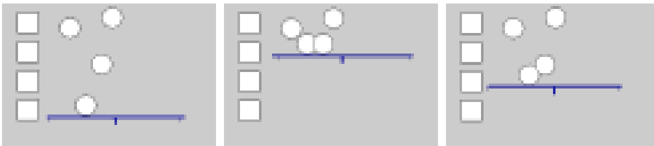

Figure 4. Backing up undoes movements.

The fact that the broom pushes objects that it touches relieves the designer of the need to select target objects. This reduces the number of mouse movements needed. Since objects are aligned and distributed interactively, designers can see and judge the results of their actions immediately, without the need to interpret geometric terms (e.g., “align left edges” or “distribute horizontal spacing”). Since the broom returns objects to their original positions when it withdraws, designers are able to preview experimental alignments without commitment. We expect that the straightforward physical analogy between the broom alignment tool and real-world push brooms will aid designers in understanding and anticipating the results of their actions. Shneiderman finds that users delight in using tools that provide “visibility of the objects and actions of interest; rapid, reversible, incremental actions; and replacement of complex command-language syntax by direct manipulation” [4].

EXPERIMENT

We performed a small study to compare the broom with standard alignment commands. Subjects created diagrams such that each diagram was done once with the broom and once with the standard alignment tools, in random order. This allowed us to compare, for each subject, whether the broom or standard commands were better for the task. Ten subjects each repeated this with three separate diagrams.

On the second and third diagrams, we tested the short-term memory of our subjects to see if the memory load was greater for one tool than for the other. Before each diagramming task, subjects memorized a set of six random, two-digit numbers, and at the beginning and end of each task they were asked to recall the numbers. This test was inspired by a recently published experiment [2].

DISCUSSION

In all thirty trials, the mouse was moved a greater distance when using the standard tools than when using the broom. On average, the mouse was moved 86% farther when using the standard tools. This was largely due to movement to a toolbar of alignment buttons at the top of the drawing area. In contrast, control-drag was used to invoke the broom. This difference would be reduced if keystrokes were assigned to each alignment command, however that would require eight new keystroke bindings and may force users to move their hands between the mouse and keyboard more.

Figure 5 charts the distance that subjects dragged the mouse. Since the broom involves dragging the mouse and dragging can be a relatively difficult, we were concerned that the broom be more physical tiring. However, over all trials, subjects dragged an average of 12,592 pixels while using standard tools and 10,809 while using the broom, which is 16% shorter. Using a paired t-test, we found the difference to be significant with $P < 0.003$. A large part of the drag distance for standard tools was done while dragging out selection rectangles. The shorter dragging distance resulted largely from the fact that objects do not need to be selected before they are aligned with the broom.

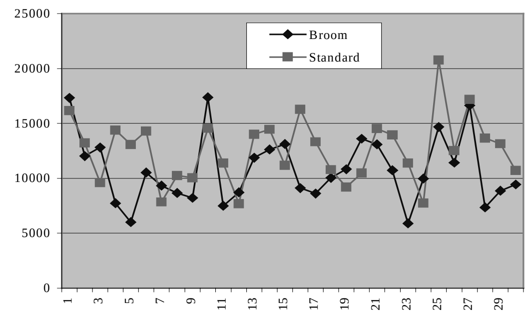

Figure 5. Mouse Dragging Distance.

Achieving layouts that show grouping and correspondence requires planning: performing alignments in the wrong order can force users to undo previous work. Since using the broom involves fewer steps, we expected a lower short-term memory load when using the broom. In fact, the majority of subjects indicated that they found the broom more “natural.” However, we found no significant difference in the short-term memory effects of the tools compared. We believe that our test for short-term memory load was not sensitive enough to detect the differences between the tools: in 26 out of 40 tasks subjects recalled all numbers perfectly.

To sum up, the broom is inspired by the observation that designers use alignment and spacing as a form of “secondary notation.” The broom provides a more natual and direct interaction style than do standard alignment tools. Our evaluation found that the broom requires less mouse movement and dragging than standard tools.

REFERENCES

1. Booch, G., Jacobson, I., and Rumbough, J. *The Unified Modeling Language User Guide*. Addison-Wesley, Reading MA, 1998.
2. Byrne, M. D. and Bovair, S. A working memory model of common procedural error. *Cognitive science 21,* 1 (1997). 31-61.
3. Green, T. R. G and Petre M. Usability Analysis of Visual Programming Environments: A ‘Cognitive Dimensions’ Framework. *J. Visual Languages and Computing 7,* 2 (June 1996). 131-174.
4. Shneiderman, B. Designing the User Interface: Strategies for Effective Human-Computer Interaction, 3rd ed. Addison-Wesley, Reading MA, 1998.