

International Journal of Advance Research in Computer Science and Management Studies

Research Article / Survey Paper / Case Study

Available online at: www.ijarcsms.com

Effects on Visual Objects

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Abstract: This paper gives reviews research on learning by getting knowledge from dynamic visual representations and offers principles for the design of animations and simulations that ensure their educational effectiveness. In addition to established principles for visual, new and revised design principles are presented that have been derived from recent research. Our review focuses on the visual design and interaction design of these visualizations and presents existing research as well as questions for future inquiry.

Keywords: Simulation, Visualization, Animation, Design.

I. INTRODUCTION

Special effects in cinema have presented the cutting edge technologies of their eras. They have even functioned as harbingers of future reality. Through examination of the direction of visual effects history, from the past to the present, we can imagine what the visual effects of the future may entail. The representation of the future by means of visual effects provides us with a vision of future reality. Thus, visual effects function as a measure of the times, of contemporaneous visions of reality and technology. The purpose of this dissertation is to chart how the development of visual effects has changed popular cinema's vision of the real, producing an ever more powerful "reality effect."

II. DIRECT AND IN DIRECT MANIPULATION

Direct manipulation works best when there is a straight-forward mapping from user actions to visible changes on the screen; typical examples include dragging an object to a new position, stretching it to make it larger, or rotating it around an origin. But some changes have no obvious map-ping (like changing an object's color), and others require more precision than can readily be achieved by direct action (like rotating an object by exact quarter turns or moving it to exactly align with another). One way to permit such operations is to provide commands that carry out the de-sired change, together with a way to invoke the commands as needed. In the context of graphical interfaces, the commands are usually invoked by pressing a button in a tool-bar or selecting a choice from a menu. We call this style of interaction in-direct manipulation, since an action on one object (a button, for instance) causes a change to another object.

III. EXAMPLE

For example we display the behavior of a manipulated object as a cartooned might: an object dragged by its corner distorts slightly, as if it has inertia. In the case of an indirect manipulation causing an object to move (perhaps to align it to another object), we would portray the change as if the object is dragged by one of its corners.

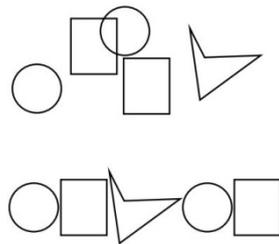


Figure 1. Before/after alignment

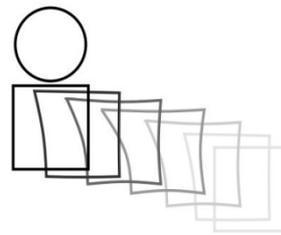


Figure 2. Animating alignment

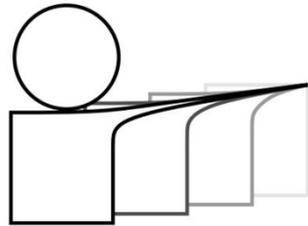


Figure 3. Previewing alignment

IV. THE PROBLEM

This research addresses two problems that often occur in indirect manipulation: an abrupt visual change can be confusing (and sometimes ambiguous), and the final result of a complex change can be difficult to predict. The visual changes caused by direct manipulation are easy for users to understand because the user focuses directly on the affected object and tracks the change as it occurs. But for changes caused by indirect manipulation, where the user's attention is focused elsewhere and the change is instantaneous, the effect can be confusing. Sudden visual changes can be disruptive because the user must subconsciously digest the new state of the screen; it takes a brief but significant moment before the new state is assimilated and the user can proceed with another task. Moreover, if the initial and final state of the screen are similar (perhaps an operation rotated a square through a quarter turn or flipped an object about an axis of symmetry), it may not be obvious just what has changed or how the change came about. To understand the changes, the user has to re-member the initial state of the screen. The user's memory may be taxed by this, and this extra load on their memory may increase the user's cognitive load for the task. For example, Figure 1 shows an operation where objects have been rearranged so that they abut left-to-right. By inspection, it is not obvious which objects in the initial configuration (top diagram) correspond to the objects in the final configuration (bottom diagram). If the screen instantaneously changes from one configuration to the other, the user may well be confused.

V. HUMAN MEMORY

Memory can be considered to have two components: working memory and long-term memory. Working memory is the temporary store used to retain new information. This is the memory that is used to calculate mental arithmetic. It is used to hold information until it can be encoded into long-term memory. Information stored in working memory is often encoded in either spatial or verbal forms, and is usually associated with a semantic representation in that awareness of meaning is associated with appearance. Wickens states that the two modes can operate in parallel and either compete or cooperate for attention. The decay of visual information is faster than for verbal. Thus visual cues are forgotten more easily than verbal cues. This can be reduced by a longer-lasting visual cue, but at the expense of visual clutter. Wickens lists six factors that influence the probability of forgetting in working memory: time, attention, capacity demands, chunking, interference, and similarity confusion. Working memory is limited in capacity, and this limit interacts with time. Faster decay is observed when more items are held in working memory. Miller identified the limit of memory span as "the magical number seven plus or minus two."

VI. ANIMATION CHANGES

Animation can help smooth abrupt changes in appearance by more gradually changing the screen's appearance from the old state to the new. These forms of smoothing animations have been investigated by a number of researchers. Whizz provides tools for building animated interactive applications. The Self animated widgets provide menus that grow, dialog boxes that dissolve, arrows that grow and shrink smoothly, and objects that can be "hit" and bounce about from moving arrows. In the "butterfly" 3D graphical menu system for Silicon Graphics workstations, activating a submenu button brings up a new menu by smoothly flipping the button over, exposing a new set of buttons. Other workers have shown that avoiding abrupt changes by smoothly changing the visual appearance of the screen over a short time interval improves understanding of the operation and can even reduce the total time needed to carry out a given task. For example, the Cone Tree and Perspective Wall visualizations (part of the Information Visualizer project) use smooth transitions to display changing views of complex data; objects slide or rotate into new configurations and views. The improvement occurs largely because a smooth change can be tracked by the user's perceptual system, whereas an abrupt change must be processed as a cognitive task.

VII. SOME CONSEQUENCES

Some indirect manipulation operations cause complex changes whose effects are difficult to predict. For example, aligning a group of objects to a common edge can cause many objects to move, all by differing amounts. Further-more, many editors offer a wide range of alignment options (by centers, by sides, equally spaced between endpoints, or abutted) in either or both the horizontal or vertical dimension. Often when the user performs the operation, the final configuration of the objects is not quite what was intended; the user might make several attempts before achieving the desired effect. One way to deal with such operations is to adopt a trial-and-error approach, with a heavy reliance on an 'undo' facility; if the final result is incorrect, it can be undone and a new attempt made. At best, such a working style is cumbersome.

VIII. NEW VISUAL CUE

When performing an alignment task, the original visual cue of using a telltale and smooth animation provides the user with a clear indication of the current and previous positions of the graphical objects. In pilot testing, subjects were able to discern the previous position of aligned objects with close to an 100% accuracy. This is not a surprising fact, given the telltale points directly back to the previous position. As an example of a typical alignment task, Figure 4(a) shows a set of graphical objects before an alignment operation, and Figure 4(b) shows the completion of the alignment. The original telltale cues for the same alignment operation are shown in Figure 4(c). These telltales dominate the visual features of the drawing. In this paper, we investigated a set of three more subtle visual cues to highlight the previous positions of aligned graphical objects. These new and novel visual effects for the user are as follows:

- **New telltale:** Objects are animated as if one of the corners is being dragged by a mouse while the remainder of the object lags behind, and a telltale is stretched back 10% towards its original position.
- **Color:** Color is used to cue the original position of the graphical object, and the object is snapped to its new location. There is a unique color for each of the original positions.
- **Wiggle:** A unique small cycling animation, or wiggle, is used to cue the original position of the graphical object. There is a different wiggle effect for each of the original positions.

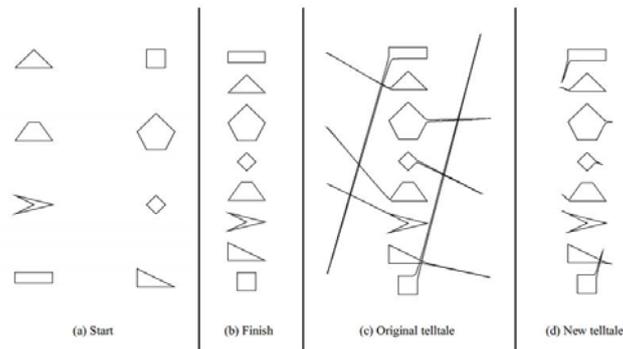


Figure 4. Example of the starting and finishing configurations for an alignment operation

The first new visual cue is a more subtle telltale effect, as shown in Figure 4(d). The telltale only stretches back 10% towards its original position. When compared to the original telltale visual cue depicted in Figure 4(c), the new telltale effect does not obscure other graphical objects and the final positions are still clear to the user. The telltale methods cue the user by explicitly referring to its previous position.

A second method is to uniquely code the original position of each graphical object. We investigated two coding strategies, color and canned animations. For the color effect, the graphical objects are drawn on a white background. We coded the eight positions depicted in Figure 4(a) with the eight colors shown in Figure 5, all of which had a large separation in the RGB color space. The choice of color is an area still to be investigated. Canned animations or wiggles are applied as a second coding strategy. Figure 6 shows the eight animations used to uniquely code the original positions. The rotate wiggle changes the orientation of the object by 5. The move wiggle translates the object by one of the following: 5 points left to right, 5 points top to bottom, or a 5 point diameter circle motion. (One printer's point or point is a 1/72 of an inch.) The scale wiggle changes the size of the object by one of the following: making the width larger and smaller by 40%, making the height larger and smaller by 40%, or making the width and height larger and smaller by 40%. The bottom right graphical object was kept still as a contrast animation effect. Once again the choice of canned animation is an area still to be investigated.

IX. EXPERIMENT

To test the effectiveness of the different visual cues, we modified our editor to use one of the four feedback techniques for alignment operations, new telltale, color, or wiggle feedback, or no feedback. During the no feedback effect, objects align with no visible feedback at all; they snap suddenly to their aligned positions. The experiment measures the subject's ability to remember the placement of graphical objects on a computer screen, in a simulated alignment operation. The subject is shown a screen of four to eight graphical objects. After a predefined time period (five seconds), the objects are automatically moved to a new location. The objects are moved with one of the four different animation effects. The subject then draws the graphical objects on the top sheet in front of them. The subject then repeats these procedures. We measured the users' performances by comparing the drawn graphical objects with their original positions, and we measured the drawing time for each task. We also asked users to complete an exit survey on their attitude to the various forms of feedback. The experiment tested the following hypotheses:

- Animation and color cues will help subjects remember the original position of objects before an alignment operation compared with feedback that does not use such cues.
- Users will prefer performing the task with visual cues over performing the task without visual cues.

X. EXPERIMENTAL DESIGN

The experimental task was to remember the positions of the objects from the configuration show in Figure 4(a) and draw them after they had aligned to the positions shown in Figure 4(b). Subjects were tested individually, working on a Silicon

Graphics Indy workstation in a quiet isolated office. The experiment supervisor read from a script to explain the requirements of the experiment and gave the following instructions:

- The subjects are shown a screen of graphical objects.
- They look at the objects, and try to remember where they are placed.
- After a five second time period, the objects are moved to a new location.
- The objects' movement is performed with one of four different animation effects, no effect, new telltale, wiggle, or color.
- The subjects then draw the graphical objects on paper in their original position.
- The task is completed by pressing the "Quit" button.

The subjects were asked to read an information sheet and a set of instructions, then asked if they had any questions. Then they were asked to sign a consent form. To familiarize themselves with the editor and the feed-back effects, each subject performed eight trials of the task, a four object and an eight object task with each feedback effect. Then each subject performed four sets of trials, each consisting of ten repetitions of the task for one of the four feedback effects. To minimize ordering artifacts, the feedback effects were presented in a random order for each subject. The graphical objects were also presented randomly in one of eight regions of the application's window. They were placed starting from the upper left corner, and the order of filling was left to right and top to bottom. The experiment took about 40 minutes for each subject to complete. The exit survey asked the subjects about their impressions of the animation effects and the task. They recorded their responses on a 7 point scale, with 1 corresponding to negative reactions ("terrible", "frustrating", "dull", "difficult") and 7 corresponding to positive reactions ("wonderful", "satisfying", "stimulating", "easy").

XI. RESULTS

The experiment was broken down into two major components, objective and subjective. The objective component measured the subject's ability to remember the correct original position of a set of graphical objects after they had been moved in an alignment style indirect manipulation operation. These results are presented first. The subjective component measured the subject's likes and dislikes of the different visual effects, and those results are presented second.

XII. CONCLUSION

The results may be applied to solve the problem of: "While an operation is being considered (but before it is committed) we wanted to show both what would happen if the operation is committed and what would happen if it were cancelled." Two strategies were investigated in this paper. One strategy was to visually show the previous position of the graphical through the use of telltales. The second strategy was to encode the initial position of the graphical objects with a unique visual effect, color or canned animation. As previously mentioned, we wished to improve on the previous telltale method by making the visual cues smaller and less obtrusive. Both the color coding and new telltale visual cues proved to be equally effective. The canned animations, or wiggles, proved to be more effective than no visual feed-back, but it was shown to be less effective than the color and telltale effects. A number of significant results were observed. These are as follows

- The subject's ability to remember the previous position was increased with the use of one of the three visual effects.
- The new telltale and color visual effects are superior to the wiggle and no visual effects.
- There was a significant effect for the number of memory items the subject was required to remember.
- The subject's preferred visual feedback was the color coding.

- Users would prefer to perform these memory tasks with some form of visual feedback.
- Once shown visual feedback for this form of task, users find having no visual feedback impedes their effectiveness.

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