The Effect of Animated Transitions in Zooming Interfaces

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ABSTRACT

Zooming interfaces use animated transitions to smoothly shift the users view between different scales of the workspace. Animated transitions assist in preserving the spatial relationships between views. However, they also increase the overall interaction time. To identify whether zooming interfaces should take advantage of animations, we carried out one experiment that explores the effects of smooth transitions on a spatial task. With metro maps, users were asked to identify the number of metro stops between different subway lines with and without animated zoom-in/out transitions. The results of the experiment show that animated transitions can have significant benefits on user performance - participants in the animation conditions were twice as fast and overall made fewer errors than in the non-animated conditions. In addition, short animations were found to be as effective as long ones, suggesting that some of the costs of animations can be avoided. Users also preferred interacting with animated transitions than without. Our study gives empirical evidence on the benefits of animated transitions in zooming interfaces.

Keywords

Animation, zooming interfaces, information visualization.

1. INTRODUCTION

Visualization systems commonly employ animated transitions to shift between different views of a workspace. Animations appear in transformations that result from navigation, rotation, hiding and revealing structure, zooming in and out of the space, or switching between detail view and overview. Designers include animations between view transitions to help a user maintain a sense of the true nature of the information when visual changes occur during view transformations. Intuitively, designers believe that smooth transitions will result in reduced time and effort as users mentally reorient themselves to the structures visible at the completion of the transformation.

While animated transitions are a common element in many interfaces, very little empirical evidence supports the effectiveness of such a feature. On one hand, intuition suggests that animated transitions may reduce the cognitive load required by the user to maintain a mental map of changes occurring in the system. However, evidence also suggests that the time delays caused by animations can be disruptive, reduce efficiency and lead to frustrations [7]. Therefore, it is important to understand whether the use of animated transitions in visual interfaces is effective.

We report the results of on an on-going project that aims at identifying instances in which animated interfaces are effective. In this paper we evaluate the effectiveness of animated transitions in zooming interfaces. In one experiment, users performed a spatial task on subway maps. Our results suggest that while animations introduce time delays, users are faster in performing certain tasks with the animation than without. Furthermore, we found that animated transition speeds can be lowered from the commonly suggested values to create more efficient animated interfaces.

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2. RELATED WORK

We review the results that have inspired our study and contrast these against some of the drawbacks of animated transitions.

2.1 The potential of animated transitions

A number of studies have investigated the potential of animated transitions. Klein and Bederson [5] demonstrate that animating the movement of the document during the scrolling operation can improve target search tasks by up to 5.3% for text targets and 24% for graphical targets. Although animation can enhance scrolling performance, Andersen [1] suggests limiting the scrolling rate to the maximum rate a target can be perceived at during animation.

Bederson and Boltman [3] examined the effects of animated viewpoint changes on a user's ability to build a mental map of the information space. The authors compared two presentation types, animated and non-animated to test the effectiveness of animation for forming spatial structures. The participants were presented with a family tree containing images of different family members. Participants were asked to assemble the structure of the family tree based on the contents of the nodes they had seen previously. In this task, subjects performed better with smooth transitions than without. However, their results showed an ordering effect, i.e., if smooth transitions were shown first, then they performed significantly better than if they were shown last.

A study by Shanmugasundaram et al [8], explored whether animated transitions facilitate perceptual constancy in node-link diagrams. In their experiments, participants were required to identify entire tree structures by inspecting parts of the hierarchy that shifted in/out of view. Their results showed that users were capable of formulating structural relationships more efficiently with animated transitions than without. Surprisingly, participants took less time with animations to complete the task, than without.

Several techniques have used smooth transitions for gradually revealing information content. Continuous semantic zooming (CSZ) developed by Schaffer et al [6] employs animations to increase content visibility. This technique is characterized by two distinct but interrelated components: continuous zooming and presentations of semantic content at various stages of the zoom operation. When a region of interest becomes the focus, the user applies the continuous zoom to "open up" successive layers of the display. At each level of the operation the technique enhances continuity through animations between views, and thereby reduces the user's sense of spatial disorientation.

Continuous semantic zooming has been applied to information structures other than topological graphs. DateLens [4] employs CSZ to reveal varying degrees of content in tabular structures in a smooth and continuous manner. An evaluation comparing DateLens to common calendar-based interactions reveals that continuous semantic zooming enhances content browsing in tabular structures. Another distortion-based interactive technique was designed by Shi et al [9] for inspecting data in nodes of a TreeMap. The distortions are smooth transitions that gradually expand the space allotted to a node. This enables users to see elements at leaf nodes without drilling-down through various layers of the hierarchy. In a study, Shi et al [9] showed that participants were able to identify content quicker and maintain context of the space better with smooth distortions.

2.2 Drawbacks of animated transitions

In spite of its advantages, animated transitions have numerous drawbacks. The most notable drawback is that animated transitions take considerable amount of time to complete a viewpoint transformation, thereby increasing system response time [3]. This additional time may not benefit users who are familiar with the task or when the task is not complex. Additionally, if animated transitions are not designed carefully, they can disrupt user performance and lead to distractions [2]. Bartram et al [2] evaluated the effectiveness of simple motion as a method of drawing the user's attention to an area of the display. Their results show that simple motion is significantly more disruptive than color or texture cues. From a design standpoint, implementing animations also requires more development effort. Additional algorithmic complexity is necessary to adequately interpolate between initial and final views of the animation. Furthermore, designers need to consider details such as the display's refresh rate or the user's hardware capacity. These constraints put an additional overhead in the development effort required for building an animated system.

In light of these drawbacks it is even more important for designers to be informed about the benefits that animations may provide. If there is evidence that animations provide significant benefits then designers may use these to outweigh the drawbacks of animated systems.

3. EXPERIMENT

The purpose of this experiment was to assess whether animated transitions are useful in zooming interfaces. Animation is applied at various steps in the zooming process thereby giving a smooth transition from zoom-in to zoom-out views, and vice versa. In an effort to create a canonical task with some ecological validity, we created a zooming interface for navigating through a spatial workspace, represented by subway maps of major cities. Subway maps have a close resemblance to a network or a node-link diagram where the subway lines appear as links and the subway stations act as nodes. The basic task was to navigate through a particular subway line and find the number of transferable intersections between two given points on that line, using zoom-in and zoom-out operations. Based on prior work we predicted the following outcomes:

Hypothesis 1: users will be more accurate when animated transitions are applied to viewpoint changes.
Hypothesis 2: completion times will be lower when animated transitions are used as in comparison to the no transition case.
Hypothesis 3: processing times (completion times - navigation time) will be the highest for the no transition case.

3.1 Method

3.1.1 Subjects

Sixteen subjects participated in this experiment (all male). All subjects were undergraduate students in computer science. The participants were regular users of mouse- and windows-based systems and had 5 to 16 years of experience with animated interfaces. They also had 3 to 8 years of experience using zooming interfaces primarily through computer gaming and map browsing applications such as Google™ and Yahoo ™ maps.

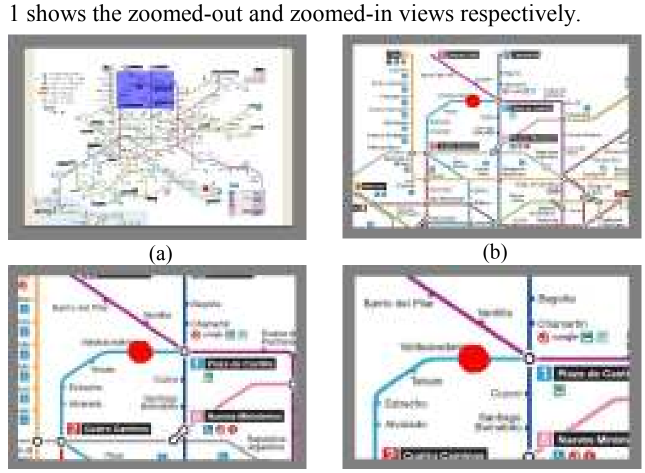
3.1.2 Materials

We used subway maps of four large cities for this experiment - Bangkok, Madrid, London and Paris. The maps were scaled to a maximum resolution of 2250x1500 pixels. We split the maps into two categories: Small (Bangkok and Madrid) and Large (London and Paris). Small maps had 6 and 8 railway lines while the large maps had more than 12 railway lines. All the railway lines were marked by a unique color.

The experimental setup was developed using .NET running on a P4 Windows XP PC system. The display was a 17" monitor set to 1280×1024 resolution. Two types of views were employed for this experiment: zoomed-out view and zoomed-in view. The system toggled between these two views through mouse clicks using either animated or no transitions. The system always started in the zoomed-out view showing the entire tube map through a viewport. Moving the mouse over the viewport would draw a small rectangular viewfinder (99x66 pixels) around the mouse pointer. Clicking the mouse button would expand the map to its maximum size and also shift the map in such a way that the region under the viewfinder would fill the entire viewport (zoomed-in view). Clicking the mouse again in the viewport would result in the zoomed-out view thereby scaling down the entire map.

3.1.3 Task

The subjects were shown one of the four subway maps in the viewport at the beginning of each trial in the zoomed-out view. Every map that was shown consisted of two highlighted points, marked in red, on a particular subway/railway line. The task was to enumerate and answer a question based on the number of transferable intersections between the two highlighted points. A transferable intersection is an intersection of two or more subway lines, where a commuter can transfer from one line to another. On the map, these transferable intersections are either shown as a single small white circle or more than two small white circles connected at the intersection of two or more subway lines. Figure 1 shows the zoomed-out and zoomed-in views respectively.



(a) (b) (c) (d)

Figure 1 - Zoom-out to zoom-in, over multiple transitions.

When smooth transitions are employed the subject was able to see a number of intermediate views thereby giving a smooth transition effect between the zoomed-out and zoomed-in views. Figures 1.b and 1.c show the viewport during transition. In contrast, when no transitions are employed the subjects would not see the map scale gradually and the net effect is that the users see the views in Figures 1.a and 1.d only. Clicking the mouse in the viewport, in the zoomed-in view, would make the system transit back to the zoomed-out view either using smooth or no transitions. The users were free to zoom-in and zoom-out as many times as they wanted to count the number of transferable intersections between the two highlighted points and answer a question. The question was always displayed below the viewport and it asked the user if the number of transferable intersections between the red dots was greater or less than a certain number. The user answered this question by clicking on the YES or NO buttons that were provided. The following data was collected for each task: Error rate, Task time and the Number of Zoom-in and Zoom-out operations. Error rate is directly related to whether users gave the right answer to the question, and the Task time is the time from the start of the task till the user clicks on the YES/NO button.

3.1.4 Design

The minimum size of the maps was 450 x 300 pixels (in the Zoomed-out view) and they expanded to a maximum size of 2250 x 1500 pixels (in the Zoom-in view). The experiment was setup using a 4x2 within-participants factorial design. The factors are:

Transition style: Slow-Transition, Medium-Transition, Fast-Transition and No-Transition

- <u>Slow-Transition:</u> this style zoomed-in or out in 1 second.
- <u>Medium-Transition:</u> zoomed-in or out in 0.5 seconds.
- <u>Fast-Transition:</u> this style zoomed-in or out in 0.25 seconds.
- <u>No-Transition:</u> this style zoomed-in or out in 1 millisecond.

Map Size: Small (6 to 8 subway/railway lines), Large (more than 12 subway/railway lines)

Transition style was fully counterbalanced using a Latin square design. The other factor was always presented in increasing order (i.e., from smaller to larger maps). Within each condition, participants carried out 4 trials. With 16 participants, 4 transition styles, 2 map sizes and 4 trials per condition, the system recorded a total of 512 trials. The system collected the total number of zoom-in and zoom-out operations, the errors and the total task time. Participants also filled out a brief questionnaire on their preferences at the end of the experiment.

3.1.5 Procedure

Participants were randomly assigned to one of the four groups obtained by counterbalancing the transition styles. Prior to starting the experiment, participants were given a small practice session which involved 2 trials per condition. After completing the practice trials, all participants indicated that they were comfortable with the four transition styles and the two types of maps being used. The participants then completed 32 trials without any breaks. At the end of the trials, the participants were asked to indicate the transition style that was easiest and the style for which they felt they performed the fastest.

3.2 Results and Discussion

We measured subjects' performance on the given task with respect to errors, task completion time and task processing time.

3.2.1 Error rate

The average error rate is summarized in figure 2 below. Average error rates were not consistent with the normality assumptions. The analysis was therefore performed on the log transform of the recorded error rates. The error rate was analyzed by means of a 4x2 (Transition Style x Map Size) one-way analysis of variance (ANOVA), with both Transition Style (Slow-Transition, Medium-Transition, Fast-Transition, No-Transition) and Map Size (Small, Large) serving as repeated measures (alpha=.05). The main effect of Transition Style was not found to be statistically significant at the 0.05 level ($F(3, 45) = 0.705$, $p = 0.554$). However the effect of Map Size was found to be significant ($F(1, 15) = 7.975$, $p = 0.013$) with the small size map mean error rate (3.9%) being smaller than the large size map mean error rate (11.3%). Finally there was no significant interaction effect between Transition Style and Map Size ($F(3, 45) = 0.442$, $p = 0.724$).

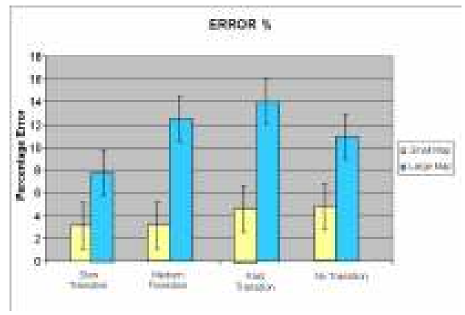


Figure 2 – Average error rates for each transition style.

Pair-wise comparisons reveal that the error rate is not significantly lower between the following transition styles: Slow-transition and Medium-transition ($p = 0.188$), Slow-transition and Fast-transition ($p = 0.173$), Slow-transition and No-transition ($p = 0.423$), Medium-transition and Fast-transition ($p = 0.609$), Medium-transition and No-transition ($p = 1.000$), Fast-transition and No-transition ($p = 0.580$). This rejects hypothesis-1 which states that users will be more accurate with smooth transitions. However pair-wise comparisons on Map size show that the smaller map error rate is significantly lower than the error rate on larger maps ($p = 0.013$).

3.2.2 Task Completion Time

The average task completion time is summarized in Figure 3. Task completion time is the amount of time (in seconds) a participant took from the moment a map was shown, till the participant gave a response by clicking on the YES/NO buttons. The completion time was analyzed by means of a 4x2 (Transition Style x Map Size) one-way analysis of variance (ANOVA), with both Transition style and Tree size serving as repeated measures. An alpha level of .05 was used for all statistical tests.

The main effect of Transition Style was found to be significant ($F(3, 45) = 7.424$, $p < 0.001$) with the average task completion time for No-transition (50.688 secs) being considerably higher than Fast-transition (35.617 secs), Medium-transition (36.453 secs), and Slow-transition (36.898 secs). The effect of Map Size was also statistically significant ($F(1, 15) = 42.685$, $p < 0.001$) with the small map average completion time (30.84 secs) being considerably lower than the completion time for larger maps (48.988 secs). We found a significant interaction effect between Transition Style and Map Size ($F(3, 45) = 3.652$, $p = 0.019$).

Pair-wise comparisons reveal that completion time for Slow-transition is not significantly lower than that of Medium-transition ($p = 0.863$) and Fast-transition ($p = 0.637$). Also, the completion time for Medium–transition is not significantly lower than the completion time for Fast-transition ($p = 0.737$), thereby suggesting that performance based on task completion times are independent of the type of smooth transitions being employed. But the completion time for No-transition is significantly higher than the completion times for Slow-transition ($p = 0.024$), Medium-transition ($p = 0.008$) and Fast-transition ($p = 0.001$). This result supports hypothesis-2, suggesting that completion times are lower when smooth transitions are used. This strongly justifies the necessity of animation in zooming based applications.

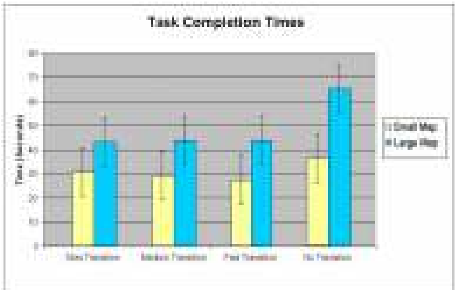


Figure 3 – Average task completion times per transition style.

3.2.3 Task Processing Time

The average processing time is summarized in Figure 4. Processing time is derived from the task completion time and the number of zoom-in and zoom-out operations. Task completion time is the time from the moment the participant starts the task to the time he/she responds by clicking the YES/NO buttons. During this time, the participant navigates the map through multiple zoom-in/-out operations, using either smooth transitions or no transition. Processing time is the task completion time minus the transition time, which is calculated from the number of zoom-in and zoom-out operations. We present our results with respect to task processing time, as it is a good measure to analyze the effect of transition style on cognitive processing ability.

The processing time was analyzed by means of a 4x2 (Transition Style x Map Size) one-way analysis of variance (ANOVA), with both Transition Style and Map Size serving as repeated measures (alpha=.05). The main effect for Transition Style was found to be statistically significant ($F(3, 45) = 18.806$, $p < 0.001$) with the participants requiring more processing time with No-transition (50.688 secs) as compared to the Slow-transition (26.563 secs), Medium-transition (30.105 secs) and Fast-transition (32.531 secs) conditions. The main effect of Map Size was also statistically significant ($F(1, 15) = 42.524$, $p < 0.001$) with the small map processing time (26.735 secs) being substantially lower than large map processing time (43.208 secs). However a significant interaction effect was found between transition style and map size ($F(3, 45) = 5.146$, $p = 0.004$).

Pair-wise comparisons show that there is no significant difference between Slow-transition and Medium-transition ($p = 0.109$) and no significant difference between Medium-transition and Fast-transition ($p = 0.271$). We found significance between Slow-transition and Fast-transition ($p = 0.025$) suggesting that Slow-transitions are better than Fast-transitions in terms of processing times. The most important point is that there is significant difference between No-transition and Slow-transition ($p < 0.001$), No-transition and Medium-transition ($p < 0.001$) and, No-transition and Fast-transition ($p < 0.001$). This result strongly supports hypothesis-3 stating that the processing times are the highest for the No-transition case.

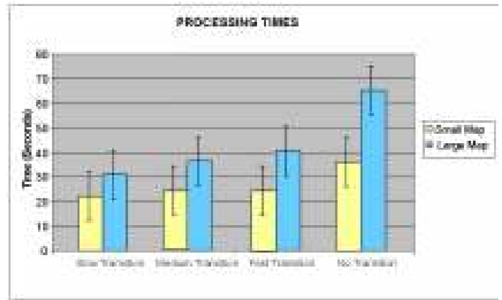


Figure 4 – Average processing times for each transition style.

3.2.4 User Preference

Participants answered two questions (Q1 and Q2) at the end of the experiment. Q1 asked them to indicate the animation style they thought was easiest and Q2 asked them to suggest the animation style that helped them complete the task faster. Fifteen out of sixteen participants rated one of the three animations as faster and easier while only a very few preferred the no-transition style.

4. Discussion and Conclusion

Overall, our analyses suggest that while participants are as accurate with animated transitions as without (reject hypothesis 1), they are approximately twice as fast with animations (support for hypothesis 2), and require much less processing with animations (support for hypothesis 3). Interestingly, we did not find any significant differences between different animation styles. This may suggest that for certain tasks, animation speeds could be reduced to ¼ of a second. This result is important as it can guide designers in integrating animated transitions in visual systems. In future work, we intend on quantifying more precisely the effects of smooth transitions with zooming or other interactive tasks, determining the correlation between transition speed and task complexity, and investigating the effects of different transition styles, such as slow-in/slow-out or variable transitions speeds on task performance.

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