Investigating the Effects of Splitting Detailed Views in Overview+Detail Interfaces

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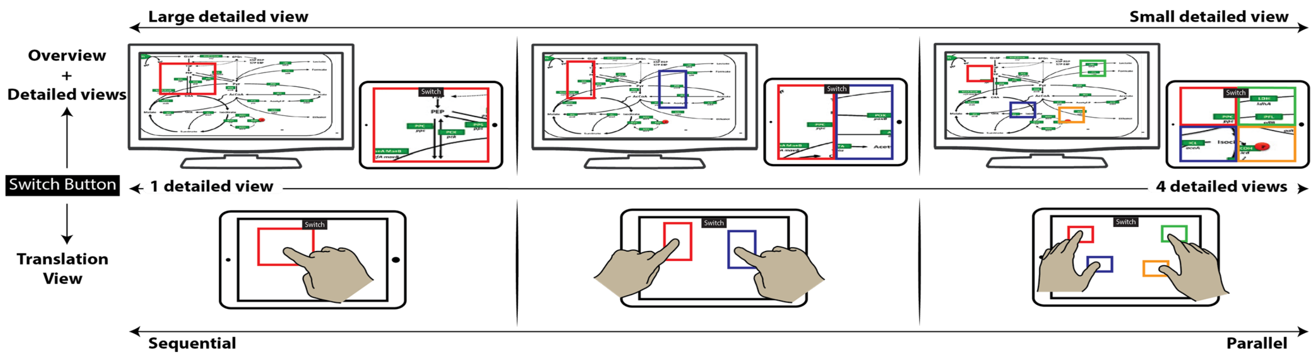

Figure 1. Arrangement of the 1, 2, 4 split-views configurations (top) and expected input control of the position of the views (bottom)

ABSTRACT

While several techniques offer more than one detailed view in Overview+Detail (O+D) interfaces, the optimal number of detailed views has not been investigated. But the answer is not trivial: using a single detailed view offers a larger display size but only allows a sequential exploration of the overview; using several detailed views reduces the size of each view but allows a parallel exploration of the overview. In this paper we investigate the benefits of splitting the detailed view in O+D interfaces for working with very large graphs. We implemented an O+D interface where the overview is displayed on a large screen while 1, 2 or 4 split views are displayed on a tactile tablet. We experimentally evaluated the effect of the number of split views according to the number of nodes to connect. Using 4 split views is better than 1 and 2 for working on more than 2 nodes.

Author Keywords

Interaction techniques; graph; multi-device; multi-surface; overview and detail; multi-view.

ACM Classification Keywords

H.5.2. Information interfaces and presentation: User Interfaces – Graphical user interfaces.

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INTRODUCTION

Overview+Detail (O+D) interfaces are a well-known approach for data visualization and manipulation [9]. These interfaces reach their limits when it comes to work on multiple regions of the overview simultaneously, e.g. connecting distant nodes of very large graphs for example. Moving the detailed view repeatedly from one region to another is tedious and interaction complexity increases with the number of regions to work on [10, 11].

To address this situation, several techniques have been designed in single or multi-display configurations to support the use of more than one detailed view simultaneously [4, 5, 9,12]. Earlier work had established a set of rules for working with multiple views [2]: the "rule of diversity" recommends the use of one view per information type and the "rule of parsimony" suggests using multiple views minimally. However none of these works has investigated the optimal number of detailed views to use, most existing techniques use 2 or 4 views. The optimal number of detailed views that will benefit complex tasks is thus still an open question.

In this paper we compare the use of different number of detailed views to interact with very large graphs in an overview + detail setting composed of a large screen and a mobile device (tablet). Our work is inspired by our collaboration with biologists using molecular interaction maps (MIMs maps [13]): these graphs can become extremely large (the Alzheimer MIM map contains 1347 nodes [13]) and complex to read or edit.

Our work aims at answering two questions: 1) are multiple detailed views better than one to interact with large graphs? and 2) what is the optimal number of detailed views needed to perform tasks with multiple graph nodes? Answering these questions is not obvious: using a single detailed view constrains the user to translate the view sequentially to each interesting region of the graph whereas using several split view allows parallel access to different locations of the graphs.

To answer these questions, we implemented an interface based on the O+D scheme. Our interface supports the simultaneous use of up to 4 detailed views independent from each other. The overview (the overall graph) is displayed on a large screen while the detailed views are displayed on a single tablet: we hereafter refer to them as the split views. Deploying O+D interfaces on multiple displays has been shown to improve data visualization and manipulation [7,15].

We experimentally compared three values for the number of split views (1, 2 or 4) in a node connection task, where the user is asked to create a link between 2, 3 or 4 nodes. These types of multi-node links are usual in large graphs such as MIMs [13].

Our contributions are 1) a study on the effects of varying the number of detailed views in O+D interfaces and 2) a discussion on the limits of multi-view O+D interfaces.

RELATED WORK

Several techniques have been designed to support interaction with large graphs, such as using the topology of links [14] or touch gestures to detect edge interactions [17]. However, these techniques do not allow working on different areas of the graph at the same time, as opposed to multi-display and multi-focus techniques.

Multi-display systems

Multi-display systems [1,6,7,15] consist in combining several displays, usually tablets, large displays and tabletops, to extend the overall interaction space; it has been proven to be useful to interact with large contexts such as geographical data [1]. Multi-display systems have been used in an overview+detail configuration [4,8]. Rashid et al. [15] found that for searching on large maps, a multi-device approach was better than a simple mobile one. Cheng et al. [7] showed that, in an overview+detail multi-surface technique, moving the position of the detail in a miniaturized view was preferred over other techniques. In our work we apply this approach to multi-view interaction.

Multi-focus techniques

The use of multiple focused views has been proposed to allow working simultaneously on multiple regions of large contexts [9,5,12]. Polyzoom [12] allows multi-scale and multi-focus exploration in 2D visual spaces by offering the user the possibility to create several hierarchies of zoomed views. Melange [9] uses a distortion-based technique that offers the possibility to bring together two regions of a large space by folding them. SpaceFold [5], inspired by Melange, introduces a multi-touch interaction technique to improve the manipulation of the folds. These previous works inspire the multi-focus technique we implemented for our study.

APPLICATION CONTEXT: MIM GRAPHS

This work was originally inspired by our collaboration with biologists carrying research on cancer. They archive knowledge in graphs called molecular interaction maps (MIM [13]). These MIM graphs contain several types of nodes (molecules, protein, etc.) and connections. There is no limit to the number of nodes that can be connected by one connection and each connection can also be connected to other connections, e.g. genes playing the role of catalysts of this connection. As research on cancer progresses, results are added to existing MIM maps, which grow extremely large, making them difficult to read and edit (see Figure 2). As a consequence of this growth, connected nodes can be located far apart from each other. In this context, using split-views would allow users to work on distant regions of MIM maps simultaneously.

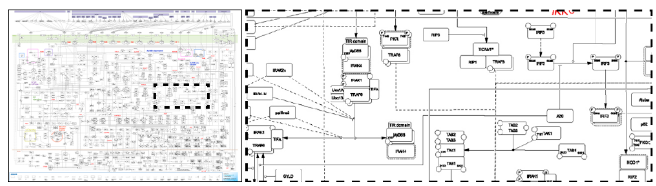

Figure 2. MIM map [13] (left) and detail (right) illustrating the density and complexity of such graphs.

INTERFACE DESIGN

We designed and implemented an O+D visualization interface that consists of a large screen to display the contextual information and a tablet to show a magnified version of selected region(s) of the large space. We describe the three main views of our interface (overview, split views and translation view) and we analyze our design with the rules for multiple views defined by Baldonado [2].

Split views

Our technique allows the user to have up to four independent split views at the same time (Fig.1), offering a detailed view on a graph region. It's also useful in supporting tasks requiring focusing on different places of the overview. We implemented three configurations for the multiple views on the tablet: 1-view, 2-views and 4-views. Using split views allows to *decompose (R3)* [2] the complex graph rendering.

With the 1-view technique, the split view occupies the entire tablet display; with 2-views, each view occupies half; and with 4-views a quarter. For all of them, the zoom level is always the same, which means that as the number of views augment, the information displayed by each view decreases. This design conforms to the *rule of consistency (R7)* as the overall detailed area size is consistent over the 3 versions of our technique and when several focus are displayed their relative size is consistent as well. It also presents different conditions of *space/time resource allocation (R5): sequential* for 1-view, and *side-by-side* for 2-views and 4-views.

Swipe gesture inside one of the split views moves the underlying graph in the same direction: this behavior is *consistent (R7)* with regular map interactions on mobile devices. Finally, when the user selects a node in one of the split views, appropriate feedback is provided so that *user's attention (R8)* is focused on the appropriate view.

Overview

The overview displays the entire graph on a large display. The ratio between the overview size and the split views size is 9 for the 1-view configuration (overview is 9 times bigger), 18 for 2-views and 36 for 4-views. These ratios were chosen to explore the effect of a zoom factor bigger than 30 (threshold identified in [18]). A contour color is applied to the split views on the tablet and to its representation on the overview to help the user establish the *relationship between the points of view (R6)* (Fig.1).

Translation view

Positioning the split views relies on the use of the translation view on the tablet, which is activated when the user presses the black button "switch" displayed on the tablet (see Fig. 1). The translation view provides a representation of the position of the 1, 2 or 4 split views on the overview. In the translation view, each split view position is represented using a **view icon**. Given the density of the graphs, displaying a miniature of it on the tablet would be useless. Therefore, the view icons are displayed on a black background. By looking at the overview, the user can use *multiple (R1)* view icons in *complementarit*y *(R2)* for selecting multiple nodes.

The user can adjust the position of one or several view icons simultaneously by direct touch manipulation as recommended in [7]. Using two hands and the multi-touch screen, the user can theoretically translate 4 view icons at the same time. Closing the translation view restores the split views. In our configuration, no zoom is allowed: this ensures a higher *consistency* over the split views *(R7)* [1].

USER STUDY

Using our multi-view technique, we conducted a controlled experiment to evaluate the effect of using multiple detailed views (1, 2 or 4) when connecting various number of nodes (2, 3 or 4) situated on different areas of large graphs.

Task

Participants were asked to create a connection between 2, 3 or 4 nodes. The overview displayed only the nodes to connect on a white background. To connect several nodes, participants had to select them by touching each node in the split views displayed on the tablet. Selecting one node required translating one of the split views displayed on the tablet so that the node becomes visible. On each trial, participants could translate each of the split views with swipe gestures directly in the split view or through the manipulation of its corresponding view icon in the translation view. Selection was validated with a single tap on the node, which was then highlighted in blue. Before each task, the position of the split-views were reset to a default position.

Node positions

To define the position of the 2, 3 and 4 nodes to connect, we decided to fix their distance from the center of the overview and change their relative distance as well as their distribution. We used eight absolute positions corresponding to the intersection of an ellipse positioned at the center of the overview with horizontal, vertical and diagonal axes. The ellipse shape is used so that the positions of the nodes are spread across the width and height of the tablet. We selected 10 combinations of these positions for each number of nodes, equilibrating the number of neighbor nodes (i.e. on consecutive positions) and the cases where all nodes were far from each other with the cases where nodes were close to each other.

Participants

We recruited 12 participants (4 females) from our local university. They were 26 years old on average (SD 4.7) and 11 of them were right-handed. All participants had used touchscreen tablets before. No specific skills were required.

Apparatus

The experimental apparatus consisted of a multi-device setting involving one PC and one tablet. The PC had a 23 inches display, showing the overview (1920x1080px). Nodes on the overview measured 15x37px. The tablet was a 10.5 inches Samsung galaxy tab S (2560x1600px). Nodes on the split views (i.e. the targets to touch) on the tablet measured 40x157px. On the translation view, each view icon measured 826x526px for 1-view configuration, 413x526px for 2-views configuration and 413x263px for 4-views configuration. A Dlink DIR-615 router was used to establish a wireless connection between the workstation and the tablet. We placed the tablet on a desk and allowed users to interact with both hands, a usual configuration in multi-display settings to avoid fatigue during long interactions and to benefit from multi-touch input [16]. The tablet rested on its cover at a 60° angle and in the same field of view than the large display, which has been shown to be paramount in multi-display environments [6]. Participants sat at 1m from the display and we ensured that there were no light reflections on the tablet.

Experimental Design

The experiment followed a 3x3 within-subject design with number of split views (NViews factor: 1V, 2V or 4V) and number of nodes to connect (NNodes factor: 2N, 3N or 4N) as factors. The NViews factor was counterbalanced by means of a 3x3 Latin square: three blocks were run, one for each value of the NViews factor. Trials in a block were grouped by the NNodes factor. Each subject performed 3 NViews x 3 NNodes x 10 predefined Node Positions x 3 repetitions = 270 trials. The training consisted of one block for each value of the NViews factor (36 trials in total). The experiment lasted 60 minutes on average.

Procedure and instructions

To begin a trial, the participant pressed a "start" button displayed in the center of the tablet. Between each block, the user was informed via an information screen that he was about to start another condition. Participants were asked to finish each trial as quickly as possible using any number of hands or fingers. They were told they could take a break if required between trials. At the end of the experiment, participants were asked to fill a System Usability Scale questionnaire (SUS).

Collected Data

We logged all touch events from the screen tablet. We measured trial completion time from stimulus onset to screen release, the number of actions to complete each trial and the number of switches between overview and split views on the tablet. We also logged the number of view icons translated simultaneously, i.e. the number of fingers performing a view icon translation at the same time.

RESULTS

We used a Shapiro-Wilk test to determine the normality of collected data. Our data could not be normalized, so we used a non-parametric Friedman test to compare more than 2 conditions and Wilcoxon tests otherwise. When needed we used the Bonferroni correction.

Completion time

Friedman tests reveal a significant effect of the NViews on completion time for each number of nodes (2N: $\chi^2(2)=22$, 3N: $\chi^2(2)=22$, 4N: $\chi^2(2)=22$ with $p<.01$). A Wilcoxon test confirms a significant difference between 1V (8652ms) and 2V (6904ms) ($Z=-2.98$, $p<.01$), and between 1V and 4V (6311ms) ($Z=-3.05$, $p<.01$). Overall, using 2V and 4V was respectively 20% and 35% faster than using 1V (Figure3). There is no significant difference between using 2V (4487ms) and 4V (4902ms) when connecting 2 nodes, but using 4V (7015ms) was 15% faster than 2V (8112ms) when connecting more than two nodes (3 nodes: $Z=-3.06$, $p<.01$, 4 nodes: $Z=-3.06$, $p<.01$).

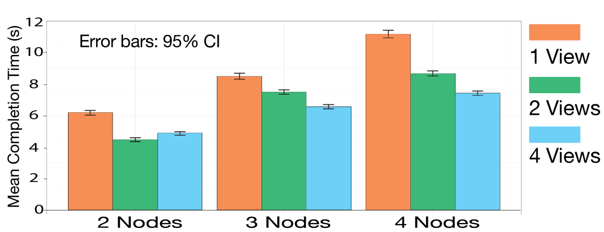

Figure 3. Trial completion time per number of nodes and number of views.

Switches between Translation and Detailed view

A Friedman test reveals a significant effect of the NViews on the number of switches between the Translation view and the Detailed view ($\chi^2(2)=18$, $p<.01$). A Wilcoxon test reveals a significant difference between 1V and 2V ($Z=-2.98$, $p<.01$), between 1V and 4V ($Z=-3.06$, $p<.01$) and between 2V and 4V ($Z=-3.06$, $p<.01$). The number of switches decreases with the NViews: 2.2 on average for 1V, 1.6 for 2V and 1.0 for 4V (see Figure **4**-Left).

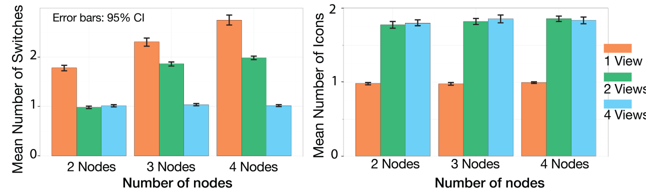

Figure 4. Left: Number of switches between the translation and detailed views. Right: Nb. of icons moved at the same time

Simultaneous icons translation

A Friedman test reveals a significant effect of the NViews on the number of view icons translated simultaneously (i.e. the number of fingers moving an icon at the same time in the translation view) ($\chi2(2)=22$, $p<.01$). A Wilcoxon test reveals a difference between 1V and 2V ($Z=-2.93$, $p<.01$), and between 1V and 4V ($Z=-3.06$, $p<.01$). For 1V, the number of icons used at the same time is slightly under 1 (0.99) because the user could pan inside the split view, without using the translation view (i.e. no icon translation).

Interestingly, we found no difference between the number of view icons translated simultaneously in 2V and 4V, even though users could employ their two hands to translate the view icons. In these conditions, whatever the number of nodes to connect, the average number of view icons translated was very similar (2V: 1,82; 4V: 1,83), even when more than 2 nodes had to be connected (see Fig. 4-Right).

We could expect users to move 3 or even 4 icons simultaneously by using a bimanual multi-touch gesture under the 4V condition. This actually happened, but in low proportion: over the 1080 trials done with 4V, 20% were performed moving only one view icon at the same time, 77% moving two icons at the same time, 2% (22 trials) moving three and 0.5% (6 trials) moving four icons (the rest 0.5% of trials did not involve moving any icon). The same user did 15 of these 22 trials (75%) performed with 3 fingers. Five participants did the other 7 trials: they tried the gesture one or two times but did not use it any longer. The analysis of the 6 trials done with four fingers raises similar results: one subject did it 2 times, and four users tried it once. Instead, moving simultaneously two icons seemed affordable for most participants. We observed that most of these bi-touch gestures were done with one finger of each hand in a bimanual coordinated gesture.

SUS Scores and User preference

SUS scores reveal that the 1V and 4V conditions were deemed good (75 and 80 respectively) while the 2V was deemed excellent (86). Interestingly, when asked, users preferred the 4V condition for the tasks where they had to work on more than two nodes while opinions were mixed for the task with two nodes only: some participants liked having four views at hand, other disliked having smaller views than under the 2V condition.

DISCUSSION AND PERSPECTIVES

In this paper, we studied the effects of splitting the detailed view in an overview+detail interface to work on large graphs. Split views were displayed on a single tablet and we evaluated three multi-view configurations: one detailed view (1V), two split views (2V) and four split views (4V). Overall, results show that using two or more split views is significantly faster than using only one detailed view. Results reveal that using 4 split views is only better than 2 split views for working on more than 2 regions of the graph.

An interesting finding of our experiment is that, when using 4 split views, users did not take full benefit of bimanual multitouch interaction to translate several view icons at the same time. Most of them (77%) used a sequential approach, first using one finger of each hand to move two icons, and then moving the two remaining view icons.

While previous work on symmetric bimanual interaction (where each hand is assigned an identical role) has already highlighted its benefit in some settings [3,19], we are only aware of one work [20] exploring symmetric bimanual *multitouch* interaction (each finger performs a pointing gesture on a different target). In this previous work, up to 47% of the trials for some tasks were performed using multiple fingers in a bimanual setting. In contrast, our results indicate that symmetric bimanual multi-touch input is hard to perform. We believe these results are dependent on the task and we need to further explore the factors influencing symmetric bimanual multi-touch interaction.

Given our findings, we plan to investigate two design questions. First, we plan to explore how to improve bimanual multitouch interaction to facilitate the translation of several split views at the same time. One idea could be to study combinations of fingers that can be moved synchronously and to help the user in employing these fingers. Second, as most participants used only one finger of each hand, we will consider other potential uses of the remaining fingers: for example additional fingers might act as modifiers to bring split views together, or to move views to specific positions such as corners.

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