

# Advanced Interaction for Information Visualization

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## ABSTRACT

Information Visualization (InfoVis) is a Research field dedicated to the design and evaluation of visual representations and interactions to explore and understand large data set. Until recently, the focus of InfoVis has been more on the representations and less on the interactions. However, several new interactive techniques have been published in the last years, opening perspectives for HCI practitioners. We describe the work at INRIA Saclay – Ile-de-France, linking traditional HCI interaction research with InfoVis interaction research. We present our latest techniques for navigating large information spaces: OrthoZoom for one dimensional (1D), Mélange for 2D, ScatterDice for high-dimensional spaces, ControlTree for large trees and Topology-aware navigation for networks. We outline their applicability in HCI problems that are not traditionally viewed as InfoVis in the hope that they will be experimented and adopted in standard interfaces and, more importantly, to emphasize the fact that interaction design for large information spaces is required for our complex user interfaces.

## Categories and Subject Descriptors

H. Information Systems H.5 Information Interfaces and Presentation H.5.2 User Interfaces (H.1.2, I.3.6)

## General Terms

Design, Experimentation, Human Factors.

## Keywords

Interaction techniques, information visualization, navigation.

## 1. INTRODUCTION

Information Visualization is about understanding large data sets, gaining insights using visual representations and interactions to explore the representations. Reading survey books on InfoVis, it is not a surprise to realize that most of the contents is dedicated to the representations themselves and much less to the interaction. [Give numbers from Readings, Ware, Spence]. Moreover, excellent books describe graphics excellence, including Bertin [5], Tufte [13] and many more.

In Information Visualization, interactions include several common tasks, summarized by Amar et al. [1]. They include navigation, selection, filtering, searching etc. We argue that the techniques designed to interact in InfoVis systems are very applicable to general user interfaces and that some of the UI

issues (e.g. menu navigation) are almost identical to InfoVis issues (e.g. tree visualization).

In the recent years, the AVIZ Team-Project at INRIA Saclay – Île-de-France has designed several interactions suitable in both context and this article describes them.

## 2. ORTHOZOOM: NAVIGATION IN LARGE 1D SPACES

Navigating a very large 1D structure, such as the PDF 1.5 manual (Figure 1) as a PDF document, the scrollbar does not allow to reach each page. Documents can be very long; a human DNA sequence is made of 3 billion base pairs. The PDF manual and a DNA sequence are also organized in a hierarchical structure to be effectively used (chapters, sections, subsections

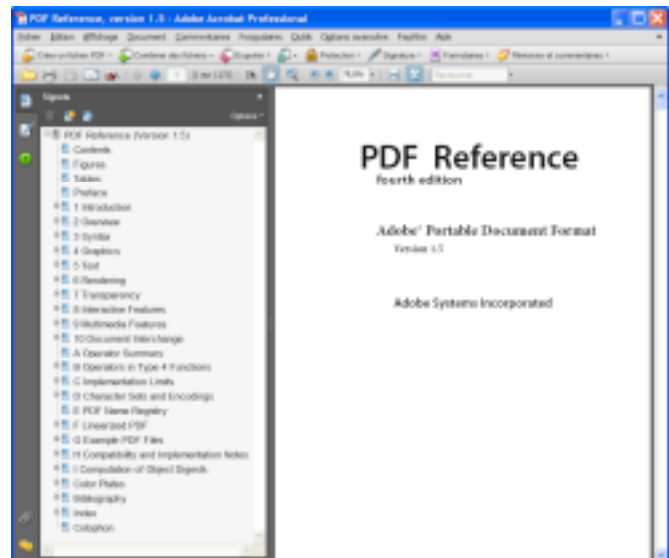


Figure 1: When scrolling a 1172 pages document with a 770 pixels scrollbar, several pages are unreachable

The OrthoZoom Scroller [4] extends a traditional slider into a 1D multi-scale navigation technique. It behaves like a traditional slider when the mouse is moved within the bounds of the slider. When dragging the mouse outside the bounds of the slider, it continuously changes the granularity/zoom of the slider (Figure 2). The granularity decreases as the mouse

cursor goes farther away from the slider bounds. In other words, moving the mouse along the slider orientation performs a pan whereas moving it orthogonally performs a zoom.

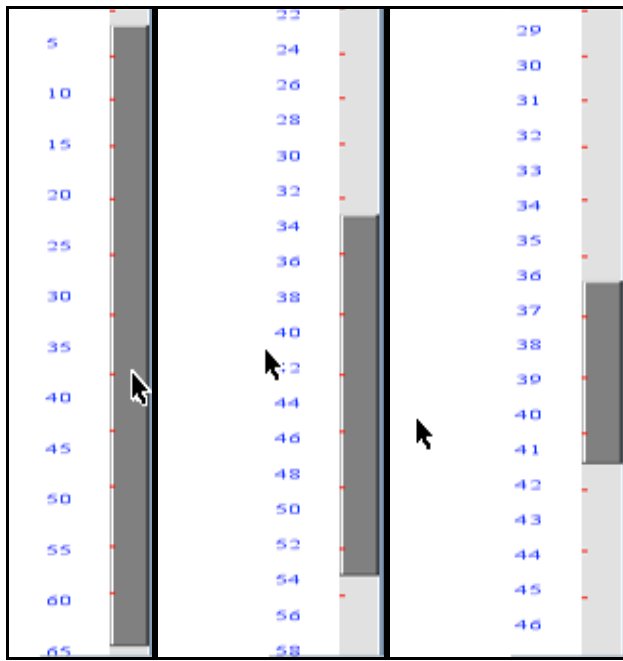


Figure 2: (a) low precision (b) medium precision (c) high precision

Using this simple technique, scrolling in 1D becomes multi-scale: the distance to the scrollbar becomes the scale selector and we navigate in a space-scale diagram [Furnas&Bederson]. We have shown that this technique was twice faster than the Speed-Dependent Automatic Zooming technique (ZDAZ), designed to navigate large 2D spaces.

OrthoZoom could seamlessly replace all the traditional scrollbars, slider and range-sliders to increase their resolution by a very large factor. Our experiments have been done up to 1 billion pages (an index of difficulty of 30 bits) but nothing prevents it to work on even larger spaces, the scrolling time increasing logarithmically with the length. OrthoZoom could as well be used for exploring large time-series data such as stock prices in the range of years, months, weeks, days, hours or minutes, which is an InfoVis issue. It can also help scroll in large textual documents which is traditionally an HCI issue.

### 3. MÉLANGE: NAVIGATION IN LARGE 2D SPACES

When visualizing social networks using adjacency matrices [10, 11], we experienced navigation issues: we wanted to compare several distant places in the matrix with some awareness of distances and important features between the focus points. Therefore, we designed the Mélange navigation method (Figure 3) that allows comparing distant portions of 2D space with some awareness of the visual features between the focus regions [8].

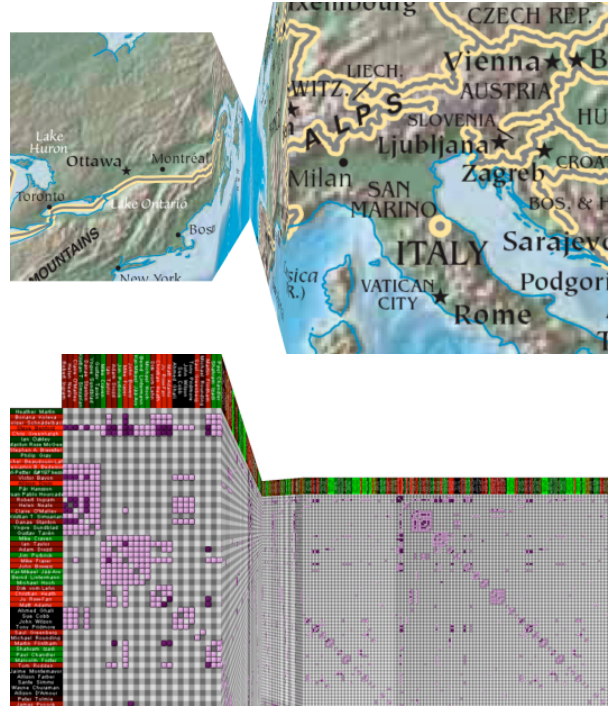


Figure 3: Mélange showing one fold on the World map (top) and on the adjacency matrix of a social network (bottom).

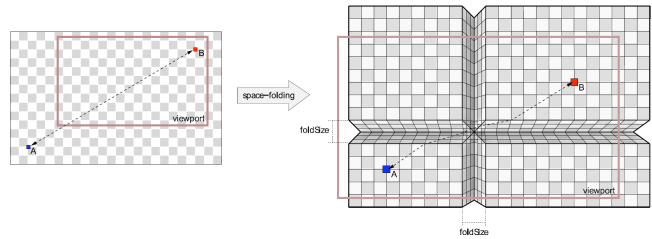


Figure 4: Folding space in 2D

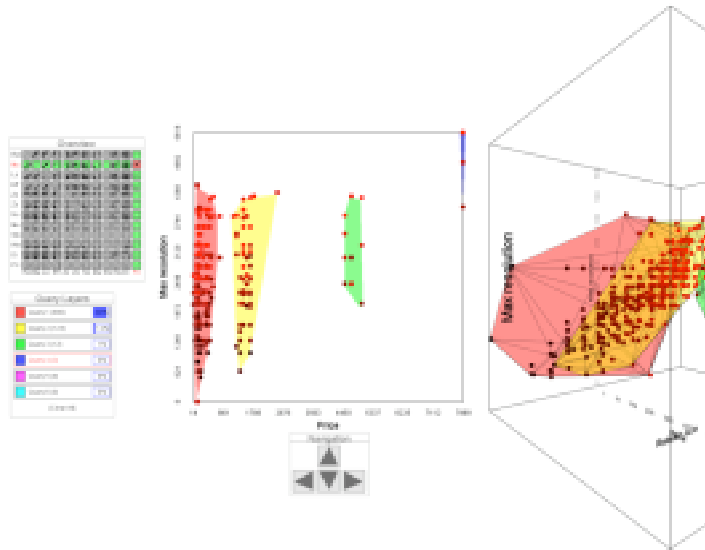
The folding can work with one or two dimensions (Figure 4) and be applied to maps, information visualization or even large spreadsheets where navigation and comparison are cumbersome. Again, the method is born from needs in the InfoVis field but the applications are far from limited to it.

### 4. SCATTERDICE: NAVIGATION IN LARGE MULTI-DIMENSIONAL SPACES

Exploring multidimensional datasets is not reserved to scientists; it is a relatively frequent operation. Choosing a digital camera among the thousands of models available is one instance: a camera is defined using several features: maker, model, price, weight, number of effective pixels, zooming range etc. A car can also be described using tens of dimensions including its fuel consumption, the number of doors etc. Understanding all the possible options when choosing these items is important to avoid missing an important feature we did not thought of at the time of purchase. To help navigate

these high-dimensional spaces, we have designed ScatterDice [7].

ScatterDice shows each item as a point in a scatter-plot. However, scatter-plot can only show two dimensions associated with a point, on the X and Y axes. Therefore, if a point is defined in 3 dimensions, we need 9 scatterplots to show all the possible assignments of axes: the X axis can be assigned the first, second or third dimension, same for the Y axis.

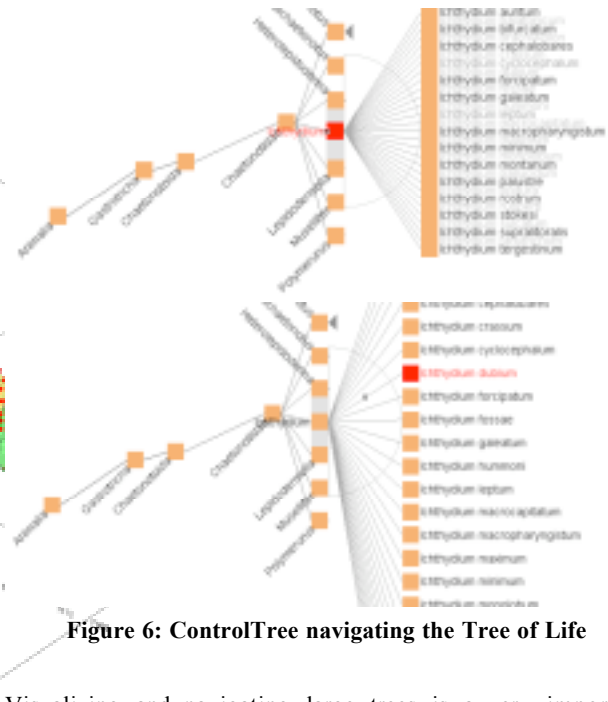


**Figure 5: ScatterDice allows users to explore a high-dimensional dataset by rolling around one dimension**

Therefore, we show a scatterplot matrix (top left of Figure 5) that presents all the combinations of assignments for a given dataset. This matrix is also used to navigate the space: each time we click on a cell, its scatterplot is displayed on the main visualization pane. One interesting point is that changing from one assignment to another is done using a smooth animation as if the points were turning in a 3D space. More precisely, when the scatterplot shows an attribute A on the X axis and an attribute B on the Y axis, changing the X axis to attribute C will be done using a rotation around the Y axis. The new attribute is virtually added as a Z axis in the 3<sup>rd</sup> dimension; then the scatterplot is extruded to become a perspective 3D view. The view is then rotated around the Y axis so that the Z axis becomes the X axis (the Y axis turning to the Z axis). Finally, the perspective scatterplot is flattened in 2D. This transition is very natural and provides a sense of continuity in the visualization. Users can track an item or a group if they want.

Smoothly exploring high-dimensional dataset using 3D rotations has been done in the HCI world, in particular with Window Managers that rotate to change virtual groups of applications. However, no systematic use of this mode of exploration has shown up in user interfaces yet. Graphics editor could show extra attributes *hidden* behind graphics objects (groupings, semantic attribute, etc.). There is a need for these kinds of simple interactions to reveal high-dimensional information that has not been explored yet in the HCI world.

## 5. CONTROLTREE: NAVIGATION IN LARGE TREES



**Figure 6: ControlTree navigating the Tree of Life**

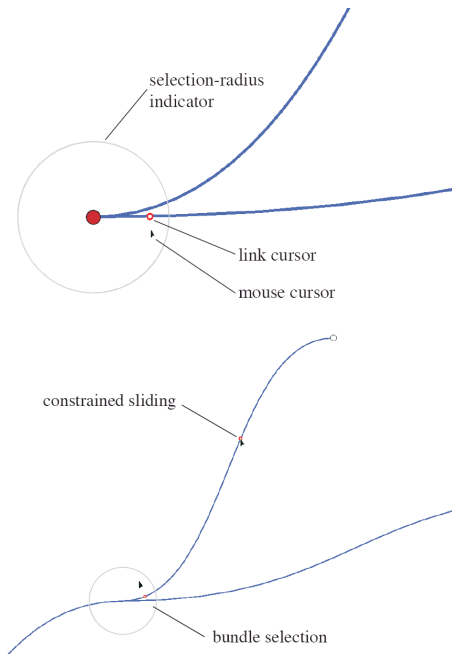
Visualizing and navigating large trees is a very important InfoVis topic. Visualizing and selecting in hierarchical menus is a very important HCI topic. It turns out hierarchical menus are tree structures so there is no real reasons to separate the two topics.

In the recent years, several systems have focused on fast tree navigation and selection, including some predictive models [6]. Keith Andrews even implemented a Tree Visualization framework to evaluate the tree visualization algorithms[2]. He called his goal “beating Microsoft Explorer” and it remains a challenge: finding tree navigation and visualization systems that could beat the existing systems on their main tasks. Catherine Plaisant has designed a nice set of tasks for tree exploration that she applied to SpaceTree [9]. As often, there are very rarely clear cut results when comparing existing systems: some system will perform better on some tasks and – so far – no system wins all, although some systems loose all.

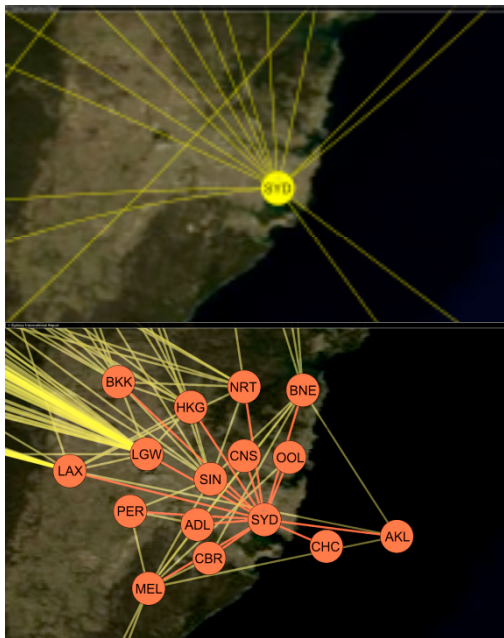
We have designed ControlTree, a visualization and interaction technique to select in large trees [3]. ControlTree uses a dynamic layout algorithm that opens the tree during the navigation and zooms dynamically to show target close to the current focus. Figure 6 shows how the tree opens when moving the mouse towards the desired target. ControlTree tries to guess the target and facilitate quick selection but its comparative evaluation shows mixed results due to complex factors such as training (Microsoft Explorer is used very frequently by a large number of users) and tasks.

Nevertheless, combining InfoVis techniques for HCI purposes (menu selection for very large menus) is again at the intersection of the two fields.

## 6. LINK-SLIDING AND BRING&GO: NAVIGATION IN LARGE NETWORKS



**Figure 7: Link Sliding Technique to quickly following a network link**



**Figure 8: Bing&Go Technique to bring the adjacent nodes in the viewport**

Finally, navigation in a large network is a typical InfoVis issue. However, it is also of great interest for common tasks such as exploring a map overlaid by a network such as roads or air lines.

In [12], we describe two new techniques to navigate large networks using information about the relations between items in a network. The first technique called Link Sliding is triggered when clicking on a node and dragging over a link (Figure 7). The link closest to the mouse is snapped as long as the mouse stays inside the visible circle. When dragging farther, an automatic pan and zoom moves the network quickly under the mouse so that a small displacement will allow reaching the target node. The viewport not only accelerate but also zooms-out to show the destination and the overview of the path.

The Bring&Go technique (Figure 8) does not accelerate the travel but brings the neighbor nodes close to the focus node, inside the viewport. Users can then click on the desired destination node that brings its neighbor until the desired final node is selected. At this point, an animation moves the viewport centered on the target node to its original location.

We have compared these two techniques to standard pan and zoom and bird eye's view – the two baseline techniques used in all the graph visualization systems – and have shown that our two techniques improve network navigation for low-level navigation tasks. Bring&Go is always significantly faster and preferred for all the tasks but Link Sliding also shows some advantages when the network is not too dense.

These techniques seem dedicated to network visualization but this is not so: several standard interactive systems maintain relationships between non-adjacent items. For example, spreadsheet calculators maintain equations between cells and seeing and navigating these relationships is currently very tedious; Link Sliding and Bring&Go could substantially accelerate the navigation. Other examples include map navigation (Figure 9), navigation in large diagrams (e.g. UML).



**Figure 9: Navigation in a map using pan and zoom is tedious when following a long uninterrupted highway portion. Link Sliding could substantially improve it.**

## 7. CONCLUSION

Navigation techniques for large information spaces have only recently received attention in the InfoVis community. Recent techniques have shown to improve navigation time while maintaining context awareness. However, these techniques are still confined to InfoVis applications when they would also improve significantly more standard HCI applications such as spreadsheet calculators, interactive maps or applications requiring navigation in general. The separation between InfoVis techniques and general HCI techniques is not relevant.

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