Poster: Towards Making InfoVis Views Tangible

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Abstract

In information visualization, interaction is commonly carried out by using traditional input devices, and visual feedback is usually given on desktop displays. By contrast, recent advances in interactive surface technology suggest combining interaction and display functionality in a single device for a more direct interaction.

With our work, we contribute to the seamless integration of interaction and display devices and introduce new ways of visualizing and directly interacting with information. For this purpose, we introduce *tangible views* as spatially-aware lightweight displays that can be interacted with by moving them through the physical space on or above a tabletop display's surface. Tracking the three-dimensional movement of tangible views allows us to control various parameters of a visualization with more degrees of freedom. Tangible views also facilitate making multiple views physically "graspable".

Keywords: Tangible views, interaction techniques, tabletop.

1 Introduction

Mouse and keyboard are the predominant interaction devices to adjust the representation according to the data and the task at hand. Compared to the richness of available visual encodings in information visualization, the number of dedicated interaction techniques for information visualization is moderate. On the other hand, visualizations printed on paper are limited in terms of interactively altering the graphics. But it is quite intuitive to grab a piece of paper, to move it towards the eyes to see more detail, and to put it back for an overview. In our research, we aim to narrow the gap between common interaction performed on the display and the natural manipulation we perform with paper. To that end, we developed what we call *tangible views*.

2 Tangible Views

This section investigates tangible views as a class of devices that serves two purposes at the same time: as a tool of representation and as a tool of interaction.

Tool of Representation In its simplest form, a tangible view is a spatially aware lightweight display or projection surface onto which arbitrary information can be projected. Tangible views usually do not exist solitarily, but instead are integrated into an environment of one or more stationary displays of arbitrary size, shape and orientation. By displaying graphical information, these stationary displays or surfaces both define and provide the contextual background of a virtual information world in which a tangible view exists. A basic display configuration will be used throughout this paper: a horizontal tabletop whose purpose is to serve as the main context view and tangible views as local views into the information space. This thinking relates to the focus + context concept.

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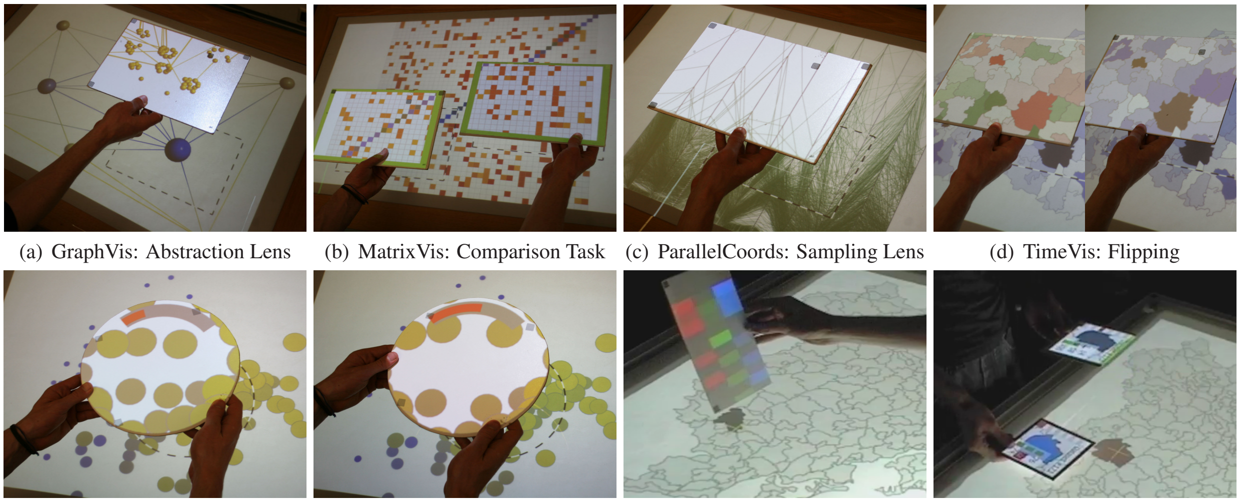
One important advantage of tangible views is that they can be used with other tangible views simultaneously. Thus, they can be understood as a multiple view environment with each tangible view representing a unique physical view into a virtual information world. This characteristic makes them an ideal tool for collaboration or comparison tasks and for supporting the overview and detail approach. Besides that, tangible views usually appear in different shapes and sizes. Most commonly a tangible view will be of rectangular or circular shape, but other more sophisticated shapes, like hexagonal or metaphorical shapes (e.g., "magnifying glass"), are possible and may play a special role during interaction.

Tool of Interaction With tangible views, we aimed at as-easy-to-learn and as-natural-as-possible usage that is inspired by everyday life interaction principles. Interacting with tangible views is basically as simple as grabbing a lightweight physical object (the tangible view) with one or both hands and then moving it around in the real-world space, while the tangible view constantly provides appropriate visual feedback. The actual interaction takes places within the physical space that is defined by the stationary display that serves as the contextual background. In our case, the space above the horizontal tabletop's surface is used as the three dimensional reference system that we refer to as the *interaction space*.

As with all solid objects in a 3D space, there are six degrees of freedom (6DOF) available for interaction. More precisely, the basic degrees of freedom are the position (x, y, z) with respect to the interaction space and the local orientation of the tangible view (α, β, γ). Corresponding interactions are translation and rotation, respectively. Both are very easy to learn and simple to execute. Additionally, interaction can be enhanced by introducing higher level interaction gestures (on the basis of basic degrees of freedom). Such gestures enrich the interaction vocabulary of users and thus can make it easier for them to solve particular sets of problems.

Interaction Vocabulary The design space for tangible views is more complex and rich than it looks at a first glance. Designers can easily come up with a multitude of ways of how users could actually work with them. Therefore, some fundamental principles need to be found and understood that help both users and system designers. By extending [2], we identified the following eight basic usage patterns for tangible views: *translation*, *rotation*, *freezing*, *gestures*, *direct pointing*, the *toolbox metaphor* as well as *multiple views*, and *visual feedback*. The first six patterns are mainly motivated by the available degrees of freedom and additional interaction modalities, and thus are features of the "tool of interaction". In contrast, the last two patterns (visual feedback, multiple views) are motivated by properties of the "tool of representation".

Translation and rotation consider the current 3D position and the local orientation of a tangible view. We introduce the possibility of freezing, to allow users to move a tangible view without the intention of interacting with the system. To enrich the interaction with tangible views, the following (non-exhaustive) set of simple gestures is supported: flipping, shaking, and tilting. In addition to interacting *with* tangible views, it is also possible to perform interaction *on* them by providing further methods of input: multi-touch and digital pen. Properties such as the shape (e.g., circle or rectangle) and the visual appearance (e.g., color or material) of a tangible view can be used as a basis for a toolbox metaphor. Users can then easily select the appropriate tool for a particular problem by its physical look. When interacting with tangible views, instant vi-



(a) GraphVis: Abstraction Lens (b) MatrixVis: Comparison Task (c) ParallelCoords: Sampling Lens (d) TimeVis: Flipping

(e) ScatterPlot: Horiz. Rotation I (f) ScatterPlot: Horiz. Rotation II (g) TimeVis: Tangible Pencil View (h) TimeVis: Time Comparison

Figure 1: Tangible views are a universal tool for information visualization that can be used, for example, to view graphs at different levels of abstraction (a), to compare different parts of a data matrix (b), to find the appropriate sampling rate in a parallel coordinate view (c), as a tangible fisheye view in a scatter plot visualization (e)+(f), or to support space-time-cube visualizations (d),(g)+(h).

sual feedback in correspondence with the interaction is presented directly on a tangible view or on the stationary tabletop display. Tangible views support the concept of multiple local views within the reference system of a global view.

3 Case Studies

The following case studies have been implemented: a *graph visualization*, a *matrix visualization*, a *scatter plot*, a *parallel coordinates plot*, and *space-time-cube visualization* (see Figure 1). Here, we describe just the graph and the matrix visualization in more detail. All case studies will be video demoed during the poster session.

Graph Visualization Node-link-diagrams and hierarchical abstraction are classic means to enable users to interactively explore large graphs. Starting at the abstraction's root, users expand or collapse nodes in a series of discrete interactions until information density suits the task at hand. A continuous navigation through the different levels of abstraction has been introduced by van Ham & van Wijk [3]. We implemented a tangible variant of such an abstraction lens and applied it to explore relations in the ACM classification. As demonstrated in Figure 1(a), a rectangular tangible view serves as a local abstraction view for the graph that is being shown on the tabletop display. Users can naturally pan the view by using *horizontal translation* and freely change the degree of detail by *vertical translation*. This way it is possible to quickly explore different parts of the graph and compare relations at different scales. At all times, the tabletop display provides *visual feedback* about the current positions of the local view within the global view.

Matrix Visualization Yi et al. [4] list visual comparison as an important interaction intent that involves various steps, as for instance, selecting subjects for the comparison, filtering the data to compare specific subjects only, or encoding of additional information to support the comparison. Performing visual comparison with traditional means is usually difficult due to the numerous heterogeneous interactions participating. On the other hand, direct interaction on a tabletop can facilitate comparison [1]. Here, we illustrate how tangible views can be applied for visual comparison. For the sake of simplicity, we use rectangular tangible views and a matrix visualization of a synthetic graph (42 nodes and 172 edges) that is displayed on the tabletop display as shown in Figure 1(b). In the first phase of comparison, tangible views are used to select data subsets. By *horizontal* and *vertical translation* users can determine position and size of a subregion of the matrix and then *freeze* the selection. Once frozen, the user can put the tangible view aside and take another one to select a second data subset. The two frozen tangible views can now physically be brought together either by holding each one in a separate hand or by rearranging them on the tabletop. As additional visual cues, smooth green and red halos around compared data regions indicate (dis)similarity. If a selection is no longer needed it can be deleted by the *shaking* gesture.

4 Summary

With *tangible views*, we hope to have made a contribution especially to the interaction side of information visualization and to stimulate a discussion on more natural ways of looking at and interacting with data. In summary, tangible views:

1. *Integrate display and interaction device.* By holding a display in the hand, one can interact *with it* in several gestural ways to change the displayed view and visualization parameters. The support of touch and pen interaction directly *on* the handheld display allows for additional interactivity.
2. *Enhance common 2D interaction with additional 3D interaction.* The usage of a "graspable" display that can be moved freely in 3D space implies a very natural way of interaction based on the metaphor of looking at pictures or documents.
3. *Replace virtual views by physical, tangible views.* Tangible views provide additional physical display space that can be utilized to support multiple coordinated views, overview & detail as well as for focus + context techniques.

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