Physical Visualizations: An Exploration

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While physical objects have been used to represent information for a long time, physical visualizations only recently started to attract attention from the InfoVis and HCI communities. My research interests are revolved around exploring the design space of physical visualizations and investigating their analytical value. I believe that physical visualizations are a fascinating area of work to combine tangible interaction and current digital fabrication methods.

Current Research

As Jansen and Dragicevic showed with their curated lists[1,2] of physical visualizations (PVs), artists and designers were involved in the design and produced a wealth of physical representations for data. They are well suited for playful exploration and stimulate curiosity and awareness [2]. As a physical object that can be explored by all senses, they are less prone to creating information overload and distress [6]. Vande Moere [4] writes that the use of physical materials as a communication medium allows for rich, cultural connotations that evoke user fascination and engagement. He argues that PVs can represent information in pleasant ways and turn data analysis in an engaging and educational experience. While these benefits are widely recognized, the analytic value of physical visualizations remains to be explored [5].

To better understand their properties, we built and experimented with PVs for a range of different datasets and in various form factors. We cut our prototypes from transparent acrylic glass using a laser cutter, which enables rapid prototyping with high precision for creating accurate PVs.

Figure 1 a) and b) show two alternative PVs of a country indicator dataset from Gapminder[3] similar to the datasets used by Jansen et al. [3]. Data is plotted along 3 dimensions to provide a compact representation. The PV consists of layered 2D plots, in which the x axis represents energy sources, the y axis countries and the z axis (layers) time (see Figure 1 c). Each data case is represented by a hole in the respective layer. The width of this hole represents the percentage of energy production from the respective source by the respective country for a given year. This PV is easy to interpret because it relies on a well-established 2D visualization. Combined with a generic dataset, people were readily able to interpret it. Moreover, it has the unique property of being articulated: Layers can be rotated independently from each other about the time axis.

[1] http://www.aviz.fr/Research/PassivePhysicalVisualizations
[2] http://www.aviz.fr/Research/ActivePhysicalVisualizations
[3] http://www.gapminder.com

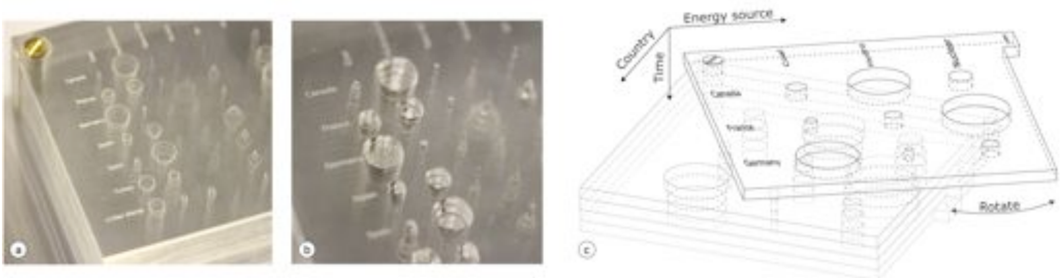

Figure 1: Two alternative physical visualizations, where each data case is represented by an engraved circle (a) or hole (b). The x axis represents energy sources, the y axis countries and the z axis time (c). Each layer can be rotated about time axis.

Based on Amar's taxonomy of analytical tasks [1], we investigated how these tasks are supported, and analyzed the benefits and drawbacks of PVs for each of these tasks. Many analytic tasks such as 'retrieve value', 'find extremum' and 'find anomalies' are be supported by PVs and they provide a particularly good overview of the data set. Some tasks require mechanical manipulation or even disassembling and reassembling the PV. The fact that PVs are three-dimensional objects, which can be visually and haptically explored from all directions, provides a very natural way of focusing on certain dimensions or cases in the data set.

Future Research

My future research will focus on exploring the design space of physical visualizations. One approach is to build new PVs based on other established digital visualizations. Another promising field of exploration is the construction of mechanically functioning visualizations, which allow dynamic exploration of a data set. I believe that other tasks, such as relating or the calculation of derived values, can be realized by more sophisticated mechanical constructions, possibly involving non-rigid, elastic parts or even liquids.
I also intend to investigate the combination of physical and digital visualizations. As physical visualizations provide a good overview of the data, digital representation can extend the physical part by displaying details-on-demand or computed values. Interacting with PVs on tabletops and augmenting PVs with projections are promising research directions.

The Tangible Interaction Studio seems to be an exciting event to present my current research ideas and meet interesting people from this community. As I am at the beginning of my PhD, this is a great opportunity to get in touch with renowned researchers, to receive valuable feedback and to gather a lot of inspiration.

References

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