Data Visualization Reimagined for Freeform Displays

La Visualisation des Données Repensée pour les Écrans Flexibles

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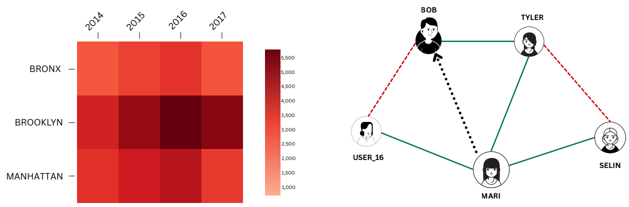
English Abstract—We present the results of an ideation and sketching workshop, in which visualization researchers reimagined how to design and adapt visualizations for freeform displays. Freeform displays are screens of non-rectangular shapes such as triangles, circles, or hexagons. Participants sketched a heatmap and a graph representation on multiple freeform shapes, with the liberty to adapt the visualization and data as they saw fit. We collected and analyzed 177 sketches and data from the interviews with the participants. We found that participants used a spectrum of strategies to adapt visualizations to the different shapes, ranging from minimal to full engagement with the form factor. We eventually aim to implement our findings as an online platform that shows types of adaptations of data visualizations to non-rectangular and, eventually, non-flat display form factors.

1 Introduction

Most visualization types are anchored to rectangular frames of reference, typically mapped into the Cartesian x/y coordinate system. As humans, however, we are collecting data by observing and interacting with a non-rectangular world, and translating this data into flat, rectangular media may be limiting our understanding of this data. As we are witnessing the advent of non-rectangular displays being commercially made available, for example, in smartwatches or embedded in public settings, researchers have begun to explore the role of visualization on freeform displays [2]. Our work falls into this research context. Specifically, we want to identify how to design and adapt visualizations for freeform displays. To find possible design strategies, we prepared and analyzed a workshop with visualization researchers who ideated and sketched visualizations on freeform shapes.

2 Related Work

The question of how to design for non-rectangular and non-flat displays has recently been the focus of a Dagstuhl seminar in which participants discussed a first set of grand challenges in this space [2]. While the seminar report [2] sets the agenda broadly, other related work on freeform displays has largely focused on general graphical content rather than data visualization specifically. For example, Serrano et al. investigated web layout principles [4] for non-rectangular form factors. Their discussion of principles such as symmetry, balance, or regularity is also useful to consider in the context of data visualization. The authors later ran design workshops to further map out the application landscape that such freeform devices could occupy [3]. Participants generated multiple ideas involving data representations. In contrast to this work, ours focuses on design principles for how data visualizations can break free from the constraints of traditional displays and be meaningfully adapted to non-rectangular, freeform display shapes. There are currently already a few techniques that fit non-rectangular screens by design, such as all circular visualizations or specific techniques such as Voronoi treemaps [1]. For most others, it is less clear how their layouts should be adapted to fit freeform displays, which is precisely our research question.



(a) Heatmap. (b) Graph.

Fig. 1: The two visualizations participants had to adapt to the freeform display shapes.

3 Ideating Visualization Workshop

To extract strategies for adapting visualizations to freeform displays, we organized a first ideation and sketching workshop, in which participants sketched existing visualizations across multiple non-rectangular form factors. We invited 9 visualization researchers from our lab with varying levels of expertise to participate in this workshop. The workshop took place as a 1-hour group sketching session in a large meeting room. We started the workshop with a short

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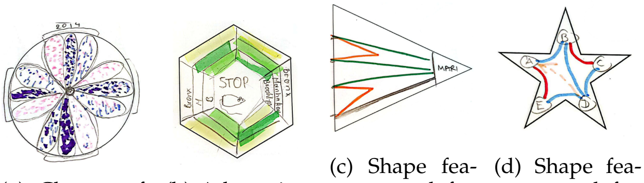

(a) Change of representation. (b) Adaptation to shape. (c) Shape features used for highlighting. (d) Shape features used for layout.

Fig. 2: Workshop sketches with (a, b) adaptations of the heatmap and (c, d) adaptation of the graph.

introduction with images of non-rectangular display form factors in real-world environments to ground the design task. Next, we introduced the first visualization, a heatmap (Fig. 1(a)), and asked participants to sketch this visualization on selected display form factors that are commercially available and deployed in public contexts: circle, thin rectangle, triangle, and a symbolic shape (e.g., star, hexagon, heart). We chose the symbolic shapes for their prevalence in our environment and established use as display form factors in selective contexts, while we selected the heatmap as a starting design because it poses an interesting challenge for non-rectangular displays, given its reliance on a rectangular frame of reference. Participants received 4 worksheets, each dedicated to a single shape type, with each shape drawn in multiple orientations, sizes, or distortions. We then prompted participants to sketch adaptations of the heatmap for 5 minutes each per worksheet, with the option to either encode the data or ignore it. We then repeated the same procedure for the second visualization (Fig. 1(b)), a directed graph with five nodes. We chose the relational graph as a second exercise because of its layout independence from any specific frame of reference. In total, we collected eight worksheets, each containing one or more sketches. Following the group sketching activity, we conducted individual interviews in which we asked participants to discuss their sketches using their own design vocabulary.

4 Sketch Analysis and First Results

Our analysis of the first workshop is currently ongoing. As part of the analysis, six researchers conducted an unconstrained card-sorting analysis of the 177 sketches. We printed each sketch on a small physical card and asked each researcher to sort the cards individually into piles based on perceived patterns or similarities regarding how designers had adapted the visualizations to freeform shapes. The objective was to determine how many design strategies emerged from these piles. Once sorting was complete, researchers named their piles and described the patterns they identified. From these descriptions, we extracted recurring themes, which informed the development of a shared vocabulary for emerging design strategies. We then constructed a co-occurrence matrix capturing how frequently any two sketches were placed in the same pile, and applied hierarchical clustering using average linkage and chi-square distance. We are currently merging this result with the pile descriptions to produce a codebook of design strategies.

Preliminary results reveal a spectrum of adaptation strategies, ranging from minimal engagement with the freeform form factor to full integration of the display shape into the visualization design. Participants who only minimally engaged with the form factor simply drew miniature versions of the original visualization. In the majority of sketches, however, participants leveraged the geometric properties of the freeform shapes to varying degrees to reframe their visualizations. Participants also attributed semantic characteristics to shapes based on factors such as orientation, pointed features, and emotional or contextual associations, which were reflected in their design choices. For example, Fig. 2(a) shows how the rectangular frame of the heatmap was changed to adapt more aesthetically to the circular shape, while in Fig. 2(b) the heatmap was taken apart and re-arranged to fit the sides of the hexagon while leaving space for labels. In Fig. 2(c) and 2(d) we see graph designs in which the corners and sides of the shapes were used to space nodes (Fig. 2(d)) or to highlight specific nodes (Fig. 2(c)).

5 Discussion and Future Work

Notably, the design strategies we identified through the card sorting, conducted by researchers with some prior context, align with those articulated by the workshop participants themselves, suggesting that the strategies we are extracting are congruent from both the designer and the viewer perspective, despite differences in vocabulary. So far, we consider our findings encouraging for the data visualization community, as they suggest it is possible to converge on a set of design strategies for adapting visualizations to freeform display shapes. Next, we will apply our final set of strategies subsequently to the post-workshop interview transcripts to trace how participants articulated their design decisions. After completing the analysis of the designs from both workshops, our goal is to build an online visualization platform where these strategies can be directly applied to transform existing visualizations on freeform shapes.

References

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