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Using Typography to Expand the Design Space of Data Visualization

Abstract This article is a systematic exploration and expansion of the data visualization design space focusing on the role of text. A critical analysis of text usage in data visualizations reveals gaps in existing frameworks and practice. A cross-disciplinary review including the fields of typography, cartography, and coding interfaces yields various typographic techniques to encode data into text, and provides scope for an expanded design space. Mapping new attributes back to well understood principles frames the expanded design space and suggests potential areas of application. From ongoing research created with our framework, we show the design, implementation, and evaluation of six new visualization techniques. Finally, a broad evaluation of a number of visualizations, including critiques from several disciplinary experts, reveals opportunities as well as areas of concern, and points towards additional research with our framework.

Keywords
Design space
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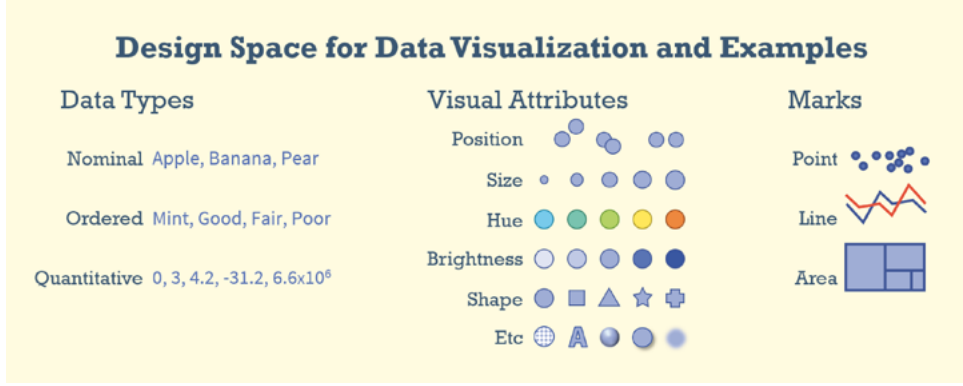

Figure 1 The design space for creating representations in data visualization: Source data of different data types are mapped to different visual attributes that are then represented as different types of marks. Image © 2016 by Author.

Introduction

In data visualization, abstract data elements like quantities or categories are encoded into visual attributes of geometry – colors, sizes and shapes – and depicted on an interactive screen or printed on paper. These visual representations act as external memory aids. They facilitate perceptual inferences – spotting outliers, estimating trends and comparing sizes, and enable higher-level tasks such as generating hypotheses and disseminating findings.[1] However, typographic attributes such as bold, italic, and font family variations are rarely used to assign meaning to the data included in visualizations,[2] suggesting a missed opportunity. Using typographic elements to expand the design space of data visualization can enable new types of visualizations, inspire novel applications within existing domains, and lead to potential new areas of economic activity.

This article provides a framework for applying typography and font attributes to data visualizations, and proposes new visualization techniques created using this framework. In the first half of the paper, we perform a systematic review of data visualization theory and practice to identify gaps in the research. We then use cross-disciplinary research to identify existing typographic attributes. These attributes are mapped back to existing research to characterize their use in data visualization, and frame the now expanded design space. In the second half of the article, we review a sample of six new data visualization techniques created using our framework, and consider some early evaluations associated with each. Finally, the results of expert critiques of the broader framework are provided.

The Field of Data Visualization

Data visualization has become a significant area of research in the last 25 years. In the domain of computer science there is a focus on effective visualization and interactive techniques, and the articulation of related data analyses, evaluations, and applications. In visualization, a key step is the transformation of data into a visual representation – called visual encoding. Early researchers, including Bertin and Card,[3] organized the encoding design space into three areas: a) data types, b) visual attributes, and c) marks, as shown in figure 1. This framework is powerful at explaining the construction of visualizations, including some well-known visualization techniques shown in figure 2. For example, the bubble plot[4] encodes quantitative data as x/y location, encodes category data as hue, and renders these using point markers of varying sizes to convey significance. The treemap[5] represents hierarchical quantities with a range of sizes and hues, and renders the data as areas within a whole. The tag cloud[6] encodes word frequencies as size – and in this particular example applies random hues – then renders the words at randomly placed points. The traditional framework continues to inform the teaching and creation of new visualization techniques, as well as formal declarative grammars.[7]

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2 Richard Brath and Ebad Banissi, "Font attributes enrich knowledge maps and information retrieval," *International Journal on Digital Libraries* (2016): 1–20, http://link.springer.com/article/10.1007/s00799-016-0168-4.

3 Jacques Bertin, *Semiology of Graphics*, trans. William Berg (Madison, WI: University of Wisconsin Press, 1983), 42–97; Stuart K. Card and Jock Mackinlay, "The Structure of the Information Visualization Design Space," in *Proceedings of IEEE Symposium on Information Visualization 1997* (Piscataway, NJ: IEEE, 1997), 92–99.

4 "Hans Rosling: The Best Stats You've Ever Seen," TED2006 video, 19:50, filmed February, 2006, https://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen?language=en.

5 Martin Wattenberg, "Map of the Market," *Martin Wattenberg—Data Visualization: Art, Media, Science* (personal website), last modified September 13, 2012, http://www.bewitched.com/marketmap.html.

6 Tag cloud created June 6, 2015, on http://wordle.net using text of Lewis Carroll's *Alice's Adventures in Wonderland*, from http://www.gutenberg.org/files/11/11-h/11-h.htm.