A Visual Survey of Arc Diagrams

Till Nagel*
KU Leuven

Erik Duval†
KU Leuven

ABSTRACT

Surveys are a common way of providing an overview over a family of visualization techniques. In this poster we focused on arc diagrams, which are an established method to visualize relations between nodes in a simple path graph, and are laid out in one dimension. We collected a wide range of examples of arc diagrams with different characteristics. Following Jürgensmann and Schulz's poster on tree visualizations we present our collection as a visual survey. As a result, our poster acts as visual reference and as inspirational source.

Keywords: Arcs, diagrams, nodes and edges, networks, survey.

Index Terms: H.5.m [Information Interfaces and Presentation]: Miscellaneous—; I.3.6 [Computer Graphics]: Methodology and Techniques—Graphics data structures and data types

1 INTRODUCTION

In recent years, data visualization has become more and more mainstream, and many visualization techniques are adapted from professionals outside the research community. Thus, there is the need to catalogue the "visualization zoo" [1] from both scholarly publications as well as from design projects.

Inspired by Jürgensmann and Schulz's poster on tree visualizations [2], we aimed to collect a wide range of examples with different characteristics, and present our collection of arc visualizations in a visual way. A visual survey makes sense for two reasons: Firstly, it seems appropriate for the graphical nature of visualizations, and secondly, it allows reaching a wider audience. Comparable to their work we focused on a specific technique. Initiated by the related work research for our Sankey Arcs technique [4] we focused on arc diagrams.

Arc diagrams are an established method to visualize relations between nodes in a simple path graph, which are laid out in one dimension. They have the ability to display multivariate node data, as well as edge properties. In their survey on visualization techniques, Heer et al. describe arc diagrams more generally as "one-dimensional layout of nodes, with circular arcs to represent links" [1]. While arc diagrams have a long history, Wattenberg popularized them as a visualization technique for displaying repeated subsequences in sequential data such as text or music [5]. Since then, arc diagrams have been applied for different data sets, from e-mail threads, to historic hotel visits, to influence relations. The technique also has been extended to cover more complex data structures (e.g., to visualize hierarchical data), to encode additional visual properties (e.g., color-coded to show categories), and to allow interactive filtering.

Furthermore - possibly due to their aesthetic appeal – they seem to be used increasingly in visualizations outside of the research community. Thus, for our survey we collected examples from scholarly publications as well as from design projects.

*e-mail:mail@tillnagel.com
†e-mail:erik.duval@cs.kuleuven.be

2 SURVEY

We reviewed publications in major outlets in visualization and interaction (such as CHI, VisWeek, EuroVis, etc), but also compilations of visualization projects from the design community (such as visualcomplexity.com, or infosthetics.com) in order to get a wider sample of arc diagrams.

As we found fewer examples from peer-reviewed publications we tended to include most of them, to get a balanced survey from both domains. Otherwise, our criteria to select a work included it to be a good example for specific characteristics, or that it was a visible project in the design community.

Not all selected examples are separate visualization techniques on their own, but differ in their characteristics or the combination thereof. Some might be seen as similar implementations of the same technique, yet still differ in some important details. We included techniques when specific variants fit our definition. For instance, the PivotGraph technique [6] is equivalent to an arc diagram in the special case of a one-dimensional layout. On the other hand, we excluded techniques which are similar but did not fully match our definition, such as Circos which displays links between circle segments [3], but is neither one-dimensional nor sequential.

Overall, we collected 41 examples. All will be exhibited and referenced on an accompanying website. From the whole collection we selected particularly illustrative examples for our poster.

3 CLASSIFICATION

Based on our collection we identified and classified properties of arc diagrams. We then grouped them into primary and secondary properties, which we will describe below.

3.1 Primary categories

The primary categories contain all characteristics which are inherent to the arc diagram itself and have semantic meaning.

- **Node distance**: Classifies the distance between single nodes into one of three groups. *Layout* contains all arc diagrams where the distance is solely decided on a design consideration, e.g., by an equi-distant algorithm. *Data* contains all diagrams where the distance is based on some node or edge value, e.g., geo-spatial distance or time. Lastly, *Metadata* contains all where the distance is based on a value of the diagram, e.g., the number of outgoing connections.

- **Node seriation**: Classifies the serial order of the nodes. They can be *intrinsic* to the data to visualize (i.e., naturally sorted such as time or space), or *extrinsic* (i.e., artificially sorted such as alphabetically). This is often closely related to Node distance.

- **Arc directionality**: Classifies the directionality of the arcs. Arc diagrams can be *non-directed*, *directed*, and – in the latter case – either uni- or bi-directional.

- **Arc weight**: Classifies whether an arc diagram is *non-weighted*, or *weighted*. Weighted arc diagrams display the strength of relations, revealing the relative and proportional connectivity weight between connected nodes, as well as clusters of connections between neighborhoods.

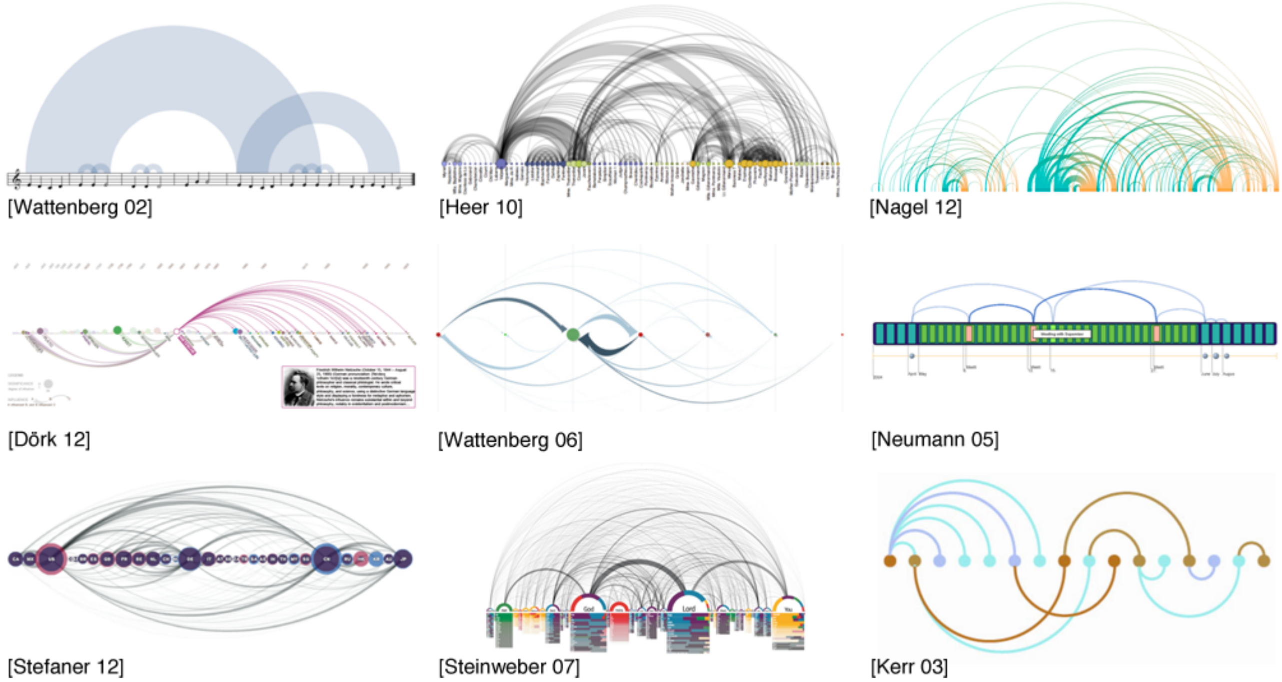

Figure 1: Examples of arc diagrams with different characteristics.

- **Degree of connection**: Classifies whether an arc diagram connects only *single* nodes, or also *multiple* ones, i.e. group of nodes. Arc diagrams of the latter typically use weighted arcs to connect, but could use other visual encodings to indicate grouping.

3.2 Secondary categories

The secondary categories are representational or visual characteristics of the concrete implementation, which have no (or much lesser) semantic meaning to the arc diagram itself.

- **Arc Type**: Classifies the visual type of the arc connection. Arc connections can be rendered as semi-circles, bezier curves, and other graphical representations.

- **Visual encoding**: Whether the arc connections have additional visual encodings, such as color or transparency. This often is used to encode semantic properties such as the directionality, but are not semantic themselves.

- **Additional visual mapping**: Whether the arc diagram have additional visual mappings, such as node size, glyphs, or complete integration of other charts and visualizations (e.g., bar diagrams).

- **Orientation**: The orientation of the arc diagram. This is typically either vertical or horizontal but can also consist of other linear orientations.

- **Sidedeness**: Classifies the number of arcs. Mostly this is either single or two-sided, but could also consist of further sides. This is related to Arc Directionality.

4 The Poster Visualization

For the poster, we used the primary properties to categorize the arc diagram implementations. The selected examples are ordered by their creation date from old to new (and if same year secondarily by their name). The top arcs visualize classification group *Arc weight* with yellow arcs connecting all examples having weighted arcs, and turquoise ones the non-weighted diagrams. The bottom arcs connect examples having directed arc visualizations.

5 Conclusion

For our visual survey on arc visualizations we collected and classified various examples with different characteristics. The poster shows a subset of these as arc visualization itself. In this way, our poster acts as visual reference and as inspirational source. It can also function as visual guide to find and select methods appropriate for ones specific project. Adding graphical indicators for the secondary properties will allow a quicker visual look-up in the future.

While a static poster only can show one way of structuring the arc visualizations, in the future we will provide different renderings of the same survey online. We also plan to allow users to change ordering, and filter projects by various classification categories.

References

[1] J. Heer, M. Bostock, and V. Ogievetsky. A tour through the visualization zoo. *Commun. ACM*, 53:59–67, June 2010.

[2] S. Jürgensmann and H.-J. Schulz. A Visual Survey of Tree Visualizations. *Poster at the IEEE InfoVis'10*, 2010.

[3] M. I. Krzywinski, J. E. Schein, I. Birol, J. Connors, R. Gascoyne, D. Horsman, S. J. Jones, and M. A. Marra. Circos: An information aesthetic for comparative genomics. *Genome Research*, 2009.

[4] T. Nagel, E. Duval, A. V. Moere, K. Kloeckl, and C. Ratti. Sankey Arcs - Visualizing edge weights in path graphs. In M. Meyer and T. Weinkauf, editors, *EuroVis - Short Papers*, pages 55–59, Vienna, Austria, 2012. Eurographics Association.

[5] M. Wattenberg. Arc diagrams: Visualizing structure in strings. In *Proceedings of the IEEE Symposium on Information Visualization*, pages 110–116, 2002.

[6] M. Wattenberg. Visual exploration of multivariate graphs. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 811–819. ACM Press, 2006.