A Guide to Visualization Guidelines for Node-Link Representations

Graphs are a quite simple data structure. They describe objects and their connections. However, the creation of its visualization is quite challenging. It encompasses the decision for the general visualization type and, additionally, the decisions for the visualization of the different visualization components. Assuming node-link diagrams, the decision space encompasses all steps of creating a graph from node and edge layout via node and edge color and form up to node labeling.

There are plenty of guidelines. They offer general readability [PSD09, HHE06, PPP12] guidelines or focus on visualization of individual components of the design space given a specific graph type (directed, general, hierarchy,âĂę). For example, layout of nodes and the routing of edges for general graphs [KDMW16, PPP12, PMCC01, MD12], the form of edges for directed graphs [HvW09], node color for trees [TdJ14], graph visualization for time-dependent graphs [APP11] or node and edge visualization in case of graph comparison [ABHR*13]. These guidelines were tested in specific graph conditions (e.g., small general graphs with low density and small world topology). When a designer draws a particular graph, then she needs to apply the right guidelines to the graph at hand. But how should the visualization designer know what to use (*actionability*) and when (scope (*generalizability*))? How should she *combine* them? And when are guidelines *transferable* to the graph at hand (e.g., from general to weighted graph)? Such guide to guidelines would be useful. However, we are not aware of a comprehensive overview of network visualization guidelines. We present a set of examples underlying this need.

1. *Generalizability* [oxf]: Is the rule tested on small graphs applicable also to large graphs? This may not be the case. For instance, Purchase et al. [PPP12, PMCC01] found that edge crossings impede graph readability. However this only holds up to a specific graph size, since Kobourov et al. [KPS14] showed that edge crossings do not matter for large graphs. This shows low degree of generalizability.

2. *Transferability*: If there is no guideline for a given graph (type, size, topology, number of graphs), the designers may wish to transfer a rule from a similar graph type. One may wish to use graph drawing guidelines from single graphs to graph comparisons. This, however may not be possible. Specific guidelines for each type such as those for weighted graph comparison [ABHR*13] may be needed. This holds also for the transfer from one graph type to another (directed vs undirected graph). Holten et al. [HvW09] showed that tapered edges are the best visualization of directed edges, but von Landesberger et al. recognized in [vLBR*16] that tapered edges are not applicable to a dense movement data graph (cf. Figure 1). Additionally, tapered edges are not suitable for weighted directed edges, thus the common visual pattern of edge thickness to encode weight is not applicable (cf. Figure 2). Also tree coloring [TdJ14] and layout orientation [BVKW11] guidelines are applicable only for the scope of trees.

3. *Actionability* [mer]: Some guidelines say what should be avoided (e.g. edge crossing [PPP12]) or explain how people read graphs [HHE06] but not state how to do a particular design decision. Other rules exactly define what should be done (e.g., which edge form is suitable [HvW09], or which edge bundling should be used [MD12]). Non-actionable guidelines provide only an indication of what a designer should be aware of, but do not really tell him what to do.

4. *Combination*: Many rules focus only on one component of the design space, and give no advice how these rules should be combined. For example, how the color of the edge influences suitable coloring of nodes. An example, why such combination is needed is the combination of node form and node layout. When a recommended graph layout (force-directed [vHR08] is used but the nodes have a specific form and size, the layout may fail. Then a layout which takes node size and form into account needs to be used.

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Keywords

Graph Visualization; Visual Graph Comparison; Network; Guidelines

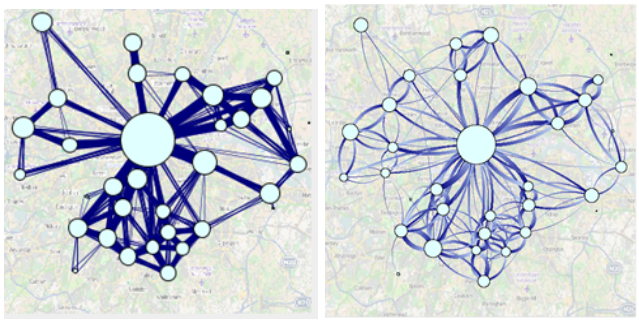

Figure 1: Example for a failing edge from guideline for dense graphs. Tapered edges do not work well for dense geo-located networks. In contras to gradients (right).

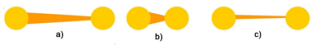

Figure 2: Example for the problem of reading edge weight for tapered edges. Shorter edges appear thicker then longer edges. Moreover, for long edges, the weight at the beginning differs from weight a tthe end. Where is the right weight to be read?

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