Geographic Network Visualization Techniques:A Work-In-Progress Taxonomy

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Abstract. This poster presents a survey of visualization techniques for geographic networks. Based on 60 techniques, we provide an initial taxonomy based on categorizing each technique across four facets: how the geographic aspect is represented, how the network aspect is represented, how these two visual representations are integrated, and whether the technique relies on user interaction. The current collection can be found online: `https://geographic-networks.github.io`.

Keywords: Geographic networks · survey · taxonomy.

1 Scope and Methodology

Geographic network data describes the relationships between geolocated entities. Examples include airports connected by commercial flights, trading networks, migration, geographic social networks or public transport networks in cities. Yet, visualizing these networks remains challenging: overlap and clutter frequently make visualizations difficult to read or even misleading. Often, there is a trade-off between computational complexity, visual quality, and the specific task at hand (analyzing geographic locations, analyzing network topology, correlating both, etc). *No taxonomy specific to these techniques exists.*

To qualify for inclusion into our survey, a paper has to either be focused entirely on geographic networks, or, at a minimum, demonstrate its applicability to geographic networks with a case study. Techniques that can theoretically be applied to geographic networks, but do not visualize the geographic aspect of the network, were not considered. Papers come from different venues: IEEE VIS, ACM CHI, EuroVis, PacificVis, and Graph Drawing. Our search resulted in 191 papers which we manually narrowed down to 40. Through additional manual search, the number increased back to 60 papers/techniques.

2 Taxonomy

A—Geographic Representation. This facet describes how the geographic aspect of the network is represented visually. We found visualizations to differ in the way they distort and abstract that geographic representation: **Map** is the least distorted technique [12, 4, 15, 14, 23, 12]. **Distorted map** includes any visualization that is still recognizable as a map, but distorted beyond the distortion introduced by the map projection [1, 15, 5, 19]. **Abstract** techniques represent geography in some non-geographic (abstract) form such as grouping nodes in a circular layout [11].

B—Network Representation. Initially, we thought to categorize according to the type of visualization. However, we quickly found that approx. 90% of all techniques use node-link diagrams, some matrices. Thus, we decided to again look for 'abstraction' in the network representation. Since a network consists of nodes *and* edges, we classify techniques along both axes: node abstraction and edge abstraction. The node representation is *explicit* when nodes are shown as points in a node-link diagram and *abstract* if not; the edge representation is *abstract* when edges are shown different than links in a node-link diagram. Another way of looking at this is whether it is theoretically possible to extract the precise network data from the visualization—independent from clutter due to potential overlap and occlusion. **Explicit nodes & explicit edges:** Includes all techniques that explicitly visualize nodes and edges: edge bundling, edge routing, 3D globes etc. [12, 14] **Explicit nodes & abstract edges:** Techniques in this category explicitly show the nodes of the network, but use abstract means of showing the connections between them. Examples include omitting edges [1] or using alternative representations [4]. **Abstract nodes & explicit edges:** Abstracting the nodes but not the edges, e.g. aggregating nodes [8, 7]. **Abstract nodes & abstract edges:** Both nodes and edges are abstracted, e.g. OD maps or aggregating both nodes and edges [21, 3].

C—Integration describes how geography and topology are integrated in the visualization, simplifying the approach in [10]. **Geography-as-basis**: The majority (44) of the surveyed visualization techniques use the geography representation as their basis and overlay a network visualization [8, 9, 3, 2, 21, 1]. A **balanced** integration is one where neither geography nor network are clearly dominant [13, 23]. **Network-as-basis:** Only one technique uses the network representation as its basis [11].

D—Interaction: classifies techniques into *none* [21, 13, 18], *optional* [4, 22], *required* [23, 6, 1], and *technique-is-interaction*; meaning that a technique is a pure interaction technique such as a fisheye lens [5], *EdgeLens* [19], link bundling [17], link plucking [20] or *Bring & Go* and *Link Sliding* [16].

3 Open Challenges

We are currently working to extend our collection and refine our taxonomy. However, many techniques remain to be explored; e.g., not taking interaction into account, there are 36 possible combinations of the different categories across facets of the taxonomy. Besides the groups discussed in the paper, we could identify the following open challenges for which we could find few or no techniques: **uncertainty** visualization of geographic positions and areas, **dynamic** geographic networks, **network-focused techniques** that preserve geography well, and precise **task and data taxonomies** that can inform future techniques, design spaces and interaction techniques.

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