A Review on Quality Assessment Metrics for Edge Bundling Techniques

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Bundling techniques used in graph drawing simplify the drawing images and make them easier to comprehend their structure for the human. We have reviewed 56 academic publications on bundling technologies and studied quantitative metrics employed to assess their effectiveness and/or served as objective functions of the proposed techniques. This poster gives a taxonomy of the proposals, identifies their tradeoffs, and exhibits further requirements for the quality assessment metrics.

What is Edge Bundling

Edge bundling is a technique for representing links drawn as straight lines on a graph drawing as curves according to their spatial similarity and integrating them. This way, graph drawing can help the discovery of groups of strongly interrelated nodes and understanding of the graph structure.

Types of Quantitative Assessment Metrics

Two types of quantitative metrics are (1) measures of ***visual clutter*** and (2) ***faithfulness***.

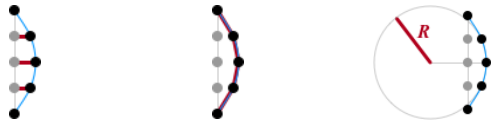
Metrics for Visual Clutter

Visual clutter quantifies difficulty in information acquisition in the graph drawing images. A purpose of the edge bundling techniques is reduction of visual clutter.

The first approach to quantify the visual clutter is ***Ink usage***. It quantifies the visual clutter of the graph drawing image by the ink usage. Ink usage is measured by counting painted pixels or by calculating the area occupied by the lines and curves.

Pixel counting based approaches measure visual clutter by the number of painted pixels used for drawing edges. ***Swarm-based edge bundling*** method introduces an evolutionary computation that tries to reduce pixel-based ink usage (Polisciuc+ 2018). ***Moving least squares edge bundling*** is a multi-purpose optimization method that minimizes pixel-based ink (Wu+ 2017). Saga defines ***Mean Occupation Area*** that represents ink usage by counting painted unit area (Saga 2018).

Geometric approaches precisely calculates ink usage instead of pixel counting. ***Multilevel agglomerative edge bundling*** method is driven by an objective function that measures ink usage by overlap of edge after bundling (Gansner+ 2011). As this measure heavily relies on their proposed algorithm, this measure is unusable for general algorithms. A metric of ***ink density distribution*** proposed by Saga favors a better bundling method gather more edges within a unit area (Saga 2018).



(a) (b) (c)

The second approach to quantify visual clutter is done by measurement of ***edge distortion*** in preference to less bent edge connections. Bundling an edge is established by ***moving control points*** initially placed on it (a). (Wu+ 2017) models distortion by ***the sum of the distances*** of control points motion (b). (Saga 2018) does with the change in the ***total lengths of the connection***. Unlike these two proposals, (Polisciuc+ 2018)'s ***curvature***-based model does not require the pre-bundled image and so applies when it is not available (c).

Metrics for Faithfulness

Faithfulness is a framework of quantifying accuracy of visualization described in (Nguyen+ 2017). They list three kinds of faithfulness.

An information theoretical formulation called ***Information faithfulness*** quantifies the information loss introduced from edge bundling. (Wu+ 2018)'s information faithfulness models the degree of misreading connection of graph edges.

Task faithfulness quantifies how accurate visualizations enough to correctly perform a task. Nguyen defined the task faithfulness for the task of finding the hub of the graph. Since his metric and task of finding hub don't seem to be logically positively correlated, his metric is inaccurate. (Nguyen+ 2017).

The last in the faithfulness framework comes the ***change faithfulness***. It quantifies the robustness of visualization method against small topological changes of the graph. Although in the context of edge bundling, to authors' knowledge, there is no attempt to incorporate the notion of change faithfulness, we believe change faithfulness is important for assessment of the edge bundling techniques.

Future Directions

We would like to propose the quality assessment metrics with the following characteristics: (1) metrics that are applicable to various algorithms and data sets and (2) task faithfulness for various task including finding hubs.

References

A list of 85 papers related to edge bundling techniques is available: