Informatics

gdMetriX

A networkX Extension for Graph Drawing Metrics

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networkX is a well established Python library for network analysis. With *gdMetriX*, we aim to extend the functionality of *networkX* and provide common metrics used in the field of graph drawing. In addition, the package provides an easy-to-use access to the 'Graph Layout Benchmark Datasets' project.

Working with gdMetriX

gdMetriX works with all types of graphs provided by *networkX*. The node positions are expected as tuples stored as node attributes with the name *"pos"*. All drawings are assumed to be straight-line drawings.

```
import networkx as nx
import gdMetriX

g = nx.Graph()
g.add_node('nodeA', pos=(0, 3.5))
g.add_node('nodeB', pos=(-3, 3))
```

In order to calculate a metric, simply call the respective function:

```
crossing_quality = gdMetriX.crossing_metric(g)
```

Loading Datasets

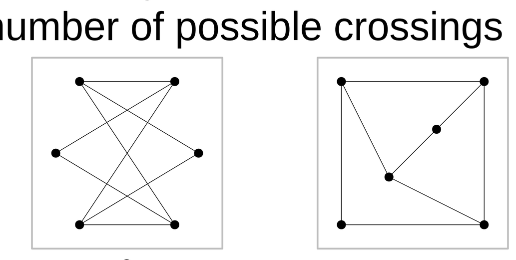
Support for automatic import of datasets (including embeddings) from the Graph Layout Benchmark Datasets project [1] with a single line of code:

```
for graph in gdMetriX.get_list_of_graphs('subways'):
    print(graph.nodes())
```

Implemented Metrics

Indispensable for collecting a set of suitable metrics were the publications by Taylor and Rodgers [2], Purchase [3], Bennett et al. [4], as well as by Mooney et al. [5].

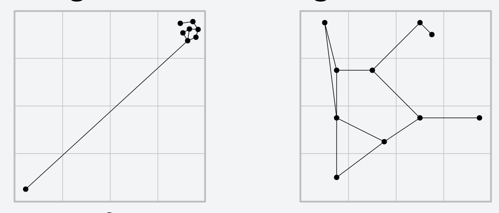
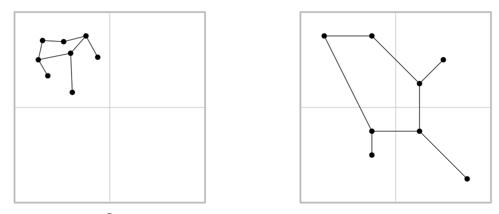
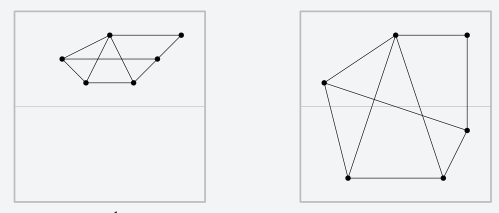
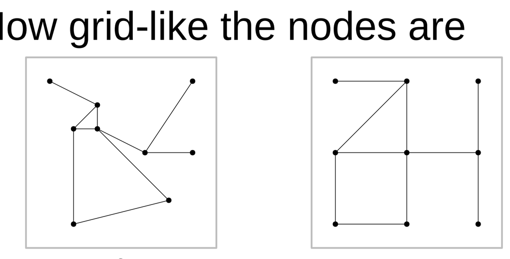
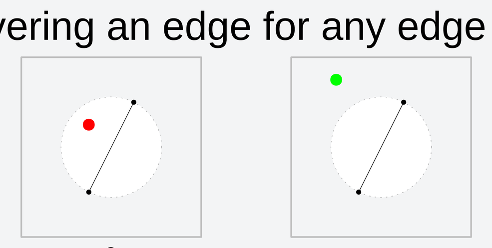
Crossings

Metric	Description	Range	
Crossing number	Implementation of the Bentley-Ottmann algorithm running in $O((n+k)\log n)$ time	$[0, \lvert E\rvert^2]$	[6]
Crossing density	Total number of crossings divided by the maximum number of possible crossings 	[0,1]	[5]
Crossing angles	List of all angles between pairwise crossing edges	$[0,\pi]$	[7]
Crossing angular resolution	Average deviation from the optimal angle between two edges in any of the crossings	[0,1]	[7]

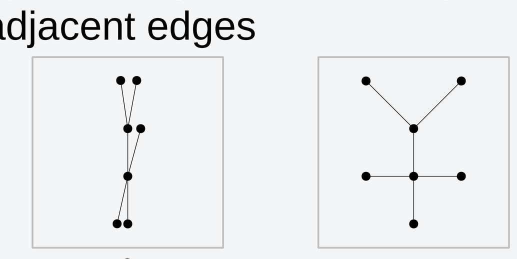
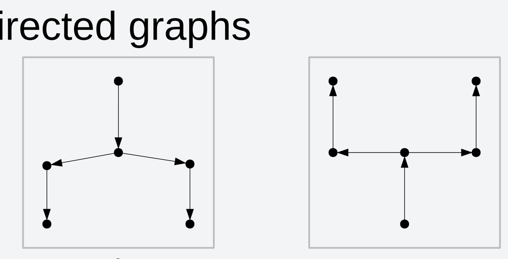
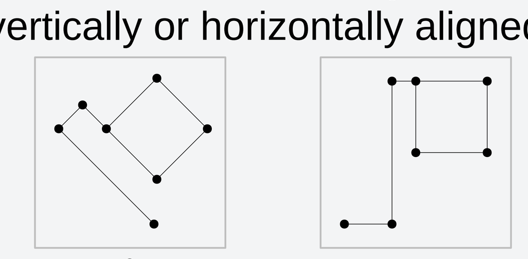
Area and Boundary

Metric	Description	Range	
Area	Size of an axis-aligned rectangular bounding box	$\mathbb{R}$	[2]
Tight area	Size of the convex hull of the graph	$\mathbb{R}$	[2]
Aspect ratio	Proportion between the smaller and the bigger side of the axis-aligned rectangular bounding box containing the graph	[0,1]	[2]

Node Distribution

Metric	Description	Range	
Center of mass	Average position of all nodes, optionally weighted by a weight vector	$\mathbb{R}^2$	
Closest pair of points	Closest pair of nodes in the drawing	V^2	[8]
Closest pair of elements	Closest pair of graph elements, i.e. points and edges	$(V \cup E)^2$	[8]
Con-centration	How evenly nodes are spread among the bounding box 	[0,1]	[2]
Homogeneity	How evenly nodes are distributed among the four quadrants 	[0,1]	[2]
Balance	Node distribution above/below axis line 	[-1,1]	[9]
Node orthogonality	How grid-like the nodes are 	[0,1]	[3]
Gabriel ratio	The percentage of nodes falling outside a minimum circle covering an edge for any edge 	[0,1]	[5]

Edge Directions

Metric	Description	Range	
Angular resolution	Average deviation from the optimal angle between any two adjacent edges 	[0,1]	[7]
Average flow	Average edge direction of a directed graph	$\mathbb{R}^2$	[4]
Upwards flow	Percentage of edges pointing 'upwards', i.e. the angle between the edge and the upward vector is <90°. For directed graphs 	[0,1]	[3]
Coherence to average flow	Upwards flow with the average flow as the 'upwards' direction, for directed graphs	[0,1]	[3]
Edge orthogonality	Extent to which the edges are vertically or horizontally aligned 	[0,1]	[3]

Symmetry

Metric	Description	Runtime	
Node-based symmetry	Estimates reflective symmetry by checking for symmetry axes along each pair of nodes	$O(n^7)$	[3]
Edge-based symmetry	Based on edge positions, estimates reflective, rotational or translational symmetry	$O(m^2)$	[10]
Stress-based symmetry	Standard definition of stress, which correlates with symmetry	$O(n^2)$	[11]
Even neigh-borhood distribution	Estimates how evenly the neighborhood of each vertex is distributed around the barycenter of the neighborhood	$O(n^2)$	[12]
Visual symmetry	Draws a constant-size image of the graph and estimates symmetry in a pixel-based manner	$O(n+m)$	No-vel

Some symmetry metrics are infeasible to obtain for certain use cases (see Fig. 1). Therefore, we have implemented an additional symmetry estimate (named "visual symmetry"), which uses a constant size pixel drawing of the graph as a basis (see Fig. 2). The measure subtracts rotated/translated/mirrored versions of the image and sums the ink left.

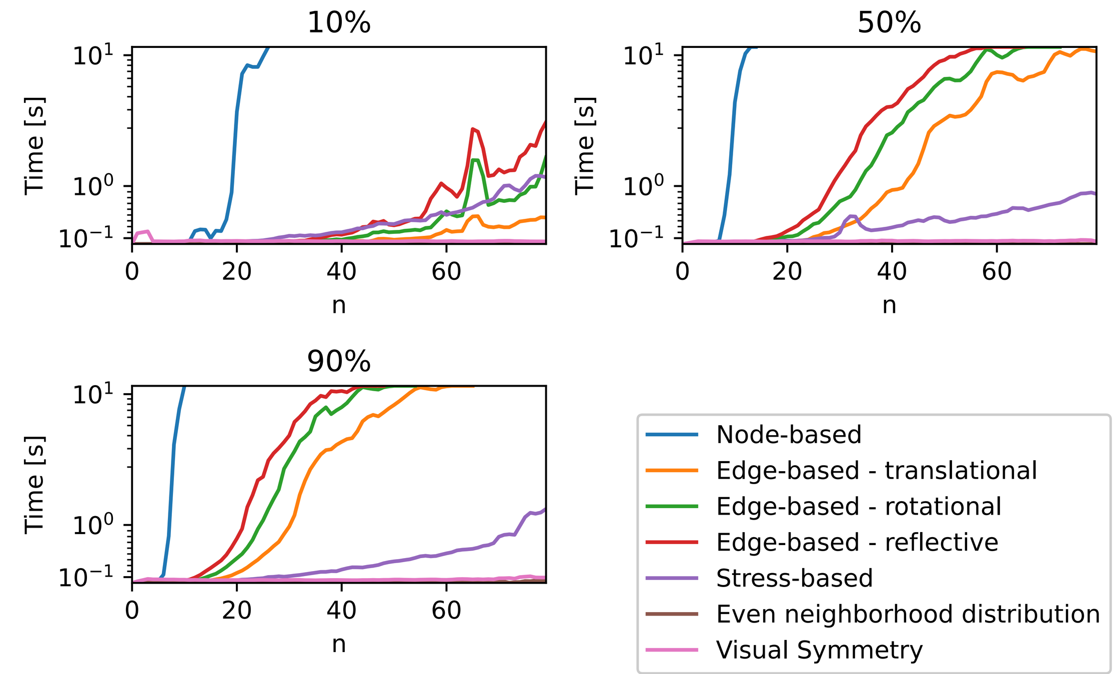


Fig. 1: Runtime of symmetry metrics with edge densities of 10-90%

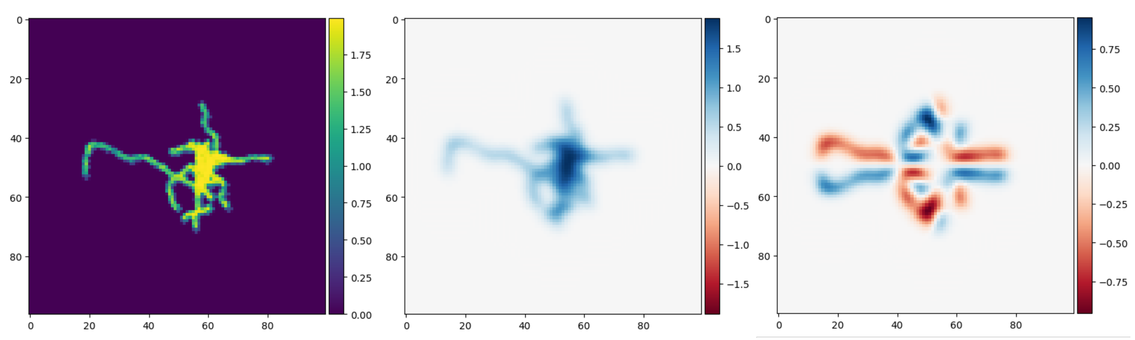


Fig. 2: Visual symmetry metric – step by step

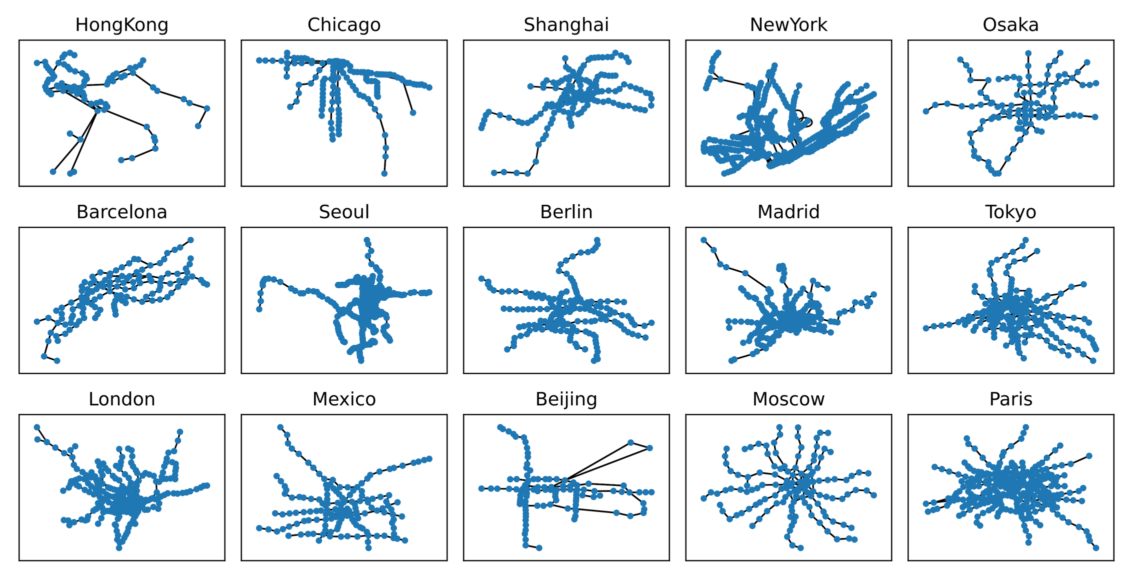


Fig. 3: Various subway maps ordered by visual symmetry from low to high.

Participation & Feedback

We hope to be able to actively maintain the project. Whether you are missing a feature, spotted a bug, or want to participate, do not hesitate to contact us.

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GitHub: https://github.com/livus/gdMetriX
Documentation: https://livus.github.io/gdMetriX/
PyPI: https://pypi.org/project/gdMetriX/

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