




An Experimental Evaluation of Viewpoint-Based 3D Graph Drawing - Supplementary Material

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1. Layout Algorithm Parameters

Each layout algorithm is run for 300 iterations, based on the default number of iterations of Stress Majorization [GKN05]. For all algorithms that use pairwise distances as input we use the graph theoretic distance matrix D .

Stress Majorization By default, Stress Majorization [GKN05] is run with eight different initializations. The layout with the smallest stress is then selected as the end result. The stress tolerance of convergence is set to $1e - 3$.

ForceAtlas2 ForceAtlas2 [JVHB14] is run using a gravity value of 1.0, a scaling ratio of 2.0 and a jitter tolerance of 1.0. Furthermore, we do not make use of the LinLog mode, barnesHutOptimization nor the strong gravity mode.

PivotMDS For PivotMDS [BP07] we set the number of pivots to $\max(5, n/10)$.

tsNET We run tsNET [KRM*17] using the parameter values as seen in Table 1.

parameter	value
momentum	0.5
tolerance	$1e - 7$
window_size	40
r_eps	0.05
lambdas2	[1, 1.2, 0]
lambdas3	[1, 0.01, 0.6]

Table 1: Parameter values of tsNET.

The perplexity value was set to a default value of 15, with certain graphs having set perplexity values, as seen in Table 2

tsNET* The tsNET* algorithm is run with the same perplexities and parameter values with one exception: lambdas2 is now equal to [1, 1.2, 0].

graph	perplexity
<i>3elt</i>	120
<i>bcsstk09</i>	80
<i>block_2000</i>	120
<i>cage8</i>	80
<i>CA-GrQc</i>	120
<i>can_96</i>	20
<i>dwt_72</i>	15
<i>dwt_419</i>	40
<i>dwt_1005</i>	40
<i>EVA</i>	600
<i>grid17</i>	40
<i>jazz</i>	120
<i>lesmis</i>	50
<i>mesh3e1</i>	40
<i>netscience</i>	80
<i>price_1000</i>	80
<i>rajat11</i>	120
<i>sierpinski3d</i>	120
<i>us_powergrid</i>	160
<i>visbrazil</i>	120

Table 2: Perplexities values of various graphs.

2. Additional Figures

2.1. RQ1

Figure 1 shows boxplots of quality metric distributions. For each metric, we acquire the quality metric values of all viewpoint layout and 2D graph layouts. We repeat this process for all graphs and layout techniques to get a singular distribution of quality metric values. In these boxplots we see that the ranges of quality metrics differ substantially. With most values of NR being close to 0 and most values of NN, NE, CN, EE being close to 1.

Figures 2-7 depict the jitterplots of the metrics CR, NR, NN, NE, EE, ELD. Here each point represents the percentage of viewpoints that score better than their 2D counterpart for a single graph. For CR (Figure 2) we observe rather similar distributions for the different layout techniques. Conversely, for NR (Figure 3) the techniques t_{sNET} and t_{sNET}^* appear to benefit the least from a viewpoint-driven approach, with few graphs having percentages above 0%. The same observations can be made for the other metrics with the exception of the ELD in Figure 7. Here, the techniques t_{sNET} and t_{sNET}^* have a large number of graphs that have large percentages of viewpoints that score better than their 2D counterparts. In all jitterplots, the technique FA2 appears to have the fewest number of graphs at 0%, indicating that this technique profits the most from the viewpoint-driven approach. Additionally, for each metric and each technique there are always a handful of graphs present that *do* benefit from the approach.

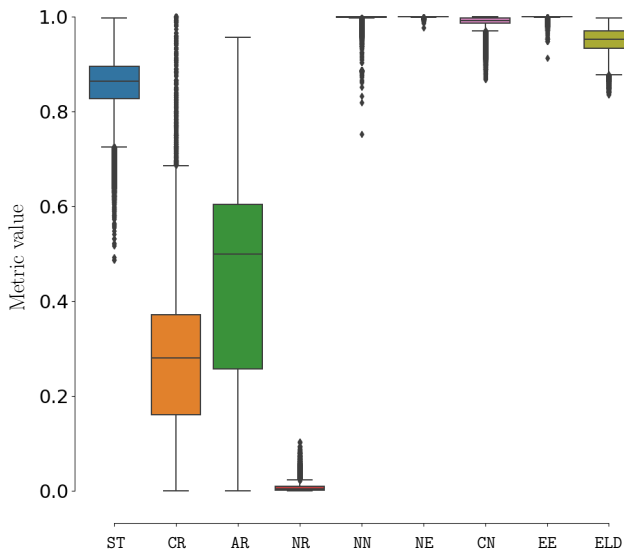


Figure 1: Boxplots representing the distributions of quality metrics, aggregated over all viewpoints from all graphs and layout techniques.

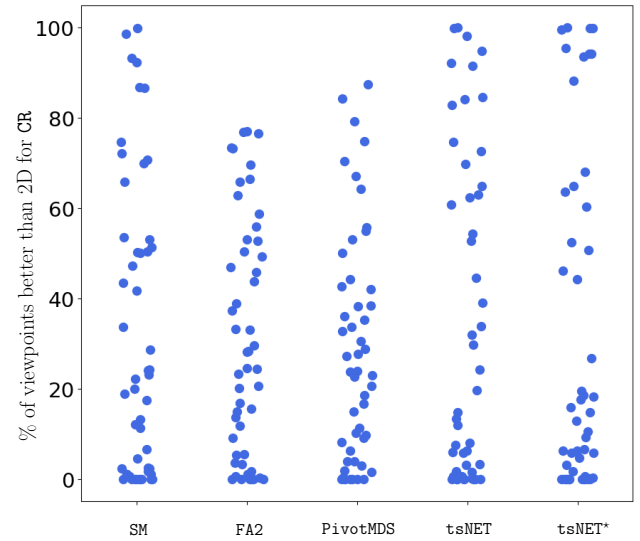


Figure 2: Jitterplots of the percentages of viewpoints that are better than their 2D counterpart w.r.t. crossing resolution, each point represents a single graph.

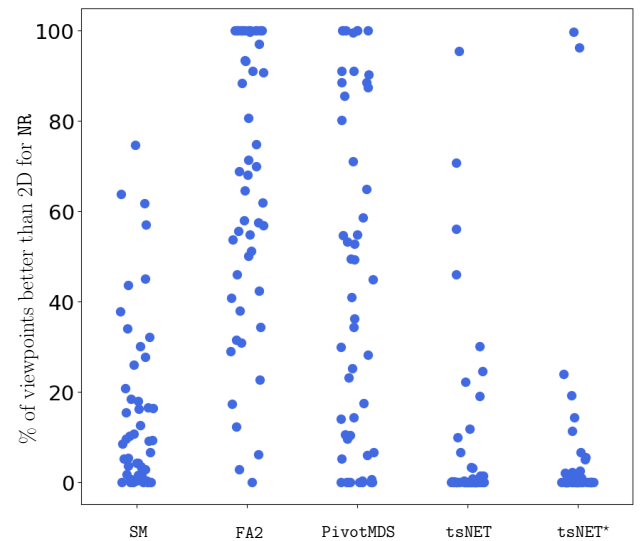


Figure 3: Jitterplots of the percentages of viewpoints that are better than their 2D counterpart w.r.t. node resolution, each point represents a single graph.

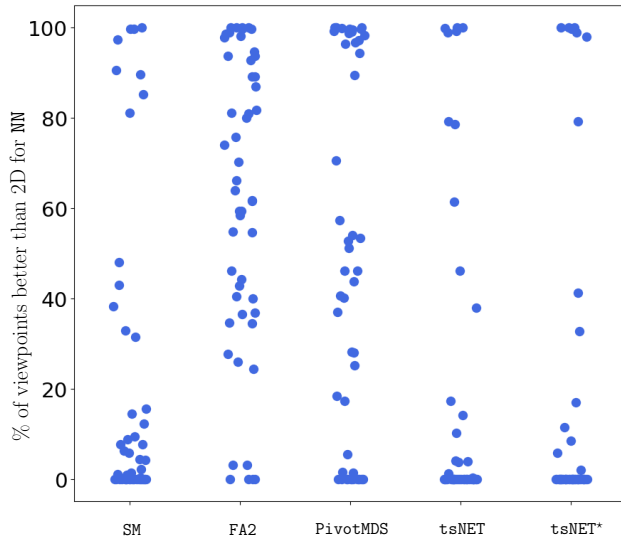


Figure 4: Jitterplots of the percentages of viewpoints that are better than their 2D counterpart w.r.t. node-node occlusion, each point represents a single graph.

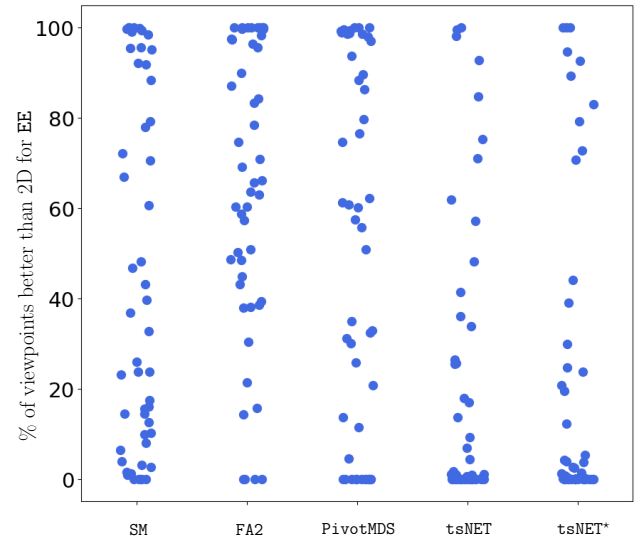


Figure 6: Jitterplots of the percentages of viewpoints that are better than their 2D counterpart w.r.t. edge-edge occlusion, each point represents a single graph.

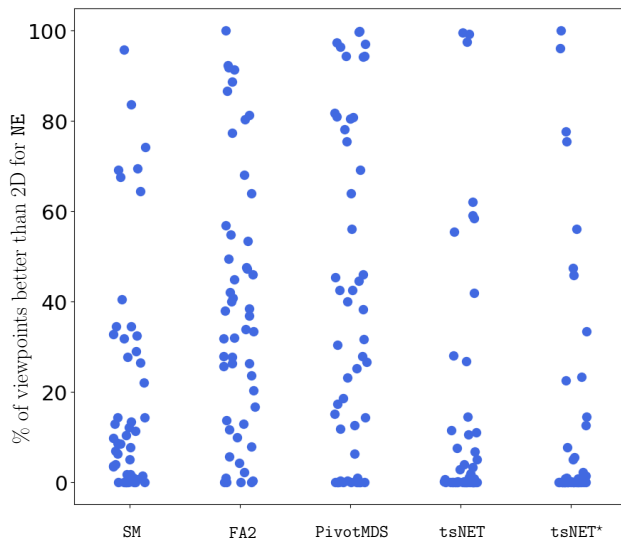


Figure 5: Jitterplots of the percentages of viewpoints that are better than their 2D counterpart w.r.t. node-edge occlusion, each point represents a single graph.

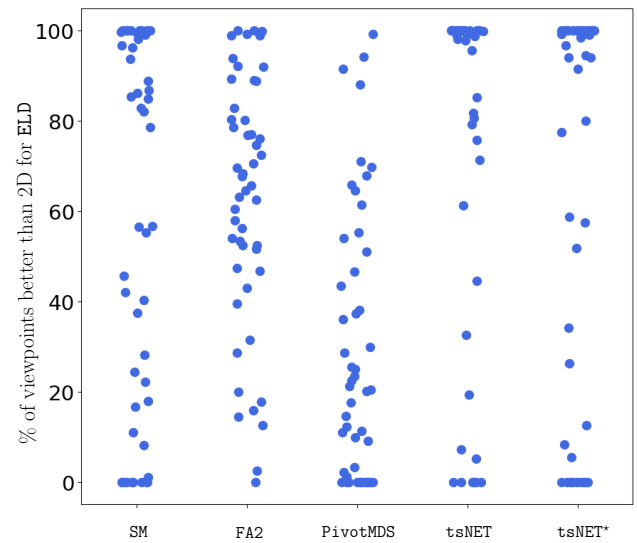


Figure 7: Jitterplots of the percentages of viewpoints that are better than their 2D counterpart w.r.t. edge length deviation, each point represents a single graph.

2.2. RQ3

Figure 8 portrays the projection scatterplots of the nine quality metric values of the 1000 viewpoints of a single graph. Here, we color the points in the projection according to the value of a single quality metric, visible on the y-axis. When observing the scatterplot of *grid17_SM* for the *crossing resolution* CR metric, we see large color differences between the two clusters. The large cluster on the left side is colored mostly red, indicating poor CR scores. Whereas the small cluster on the right side is colored light blue, indicating high quality layouts. These coloring differences explain the reason for the existence of two separate clusters, i.e. drastic differences in the CR scores lead to the formation of clusters when using dimensionality reduction. For the other metrics, the differences in colors between clusters are not too large, with the exception of ST for some graphs such as *mesh3e1_SM*.

To observe the effect of the CR metric in the creation of these projections, we repeat the same dimensionality reduction approach but *exclude* the CR dimension, thus only having eight quality metrics per viewpoint layout. The resulting scatterplots can be seen in Figure 9. We observe that there no more distinct clusters visible in the scatterplots. Therefore, we conclude that the clusters in Figure 8 were created due to the existing variation in the CR metric. In Figure 9, the metrics with the largest color differences, and can thus explain the most about the shape of the projection, are ST and AR. Though for some graphs, such as *rajat11_tsNET* other metrics (CN, ELD) appear to be able to explain more than ST and AR.

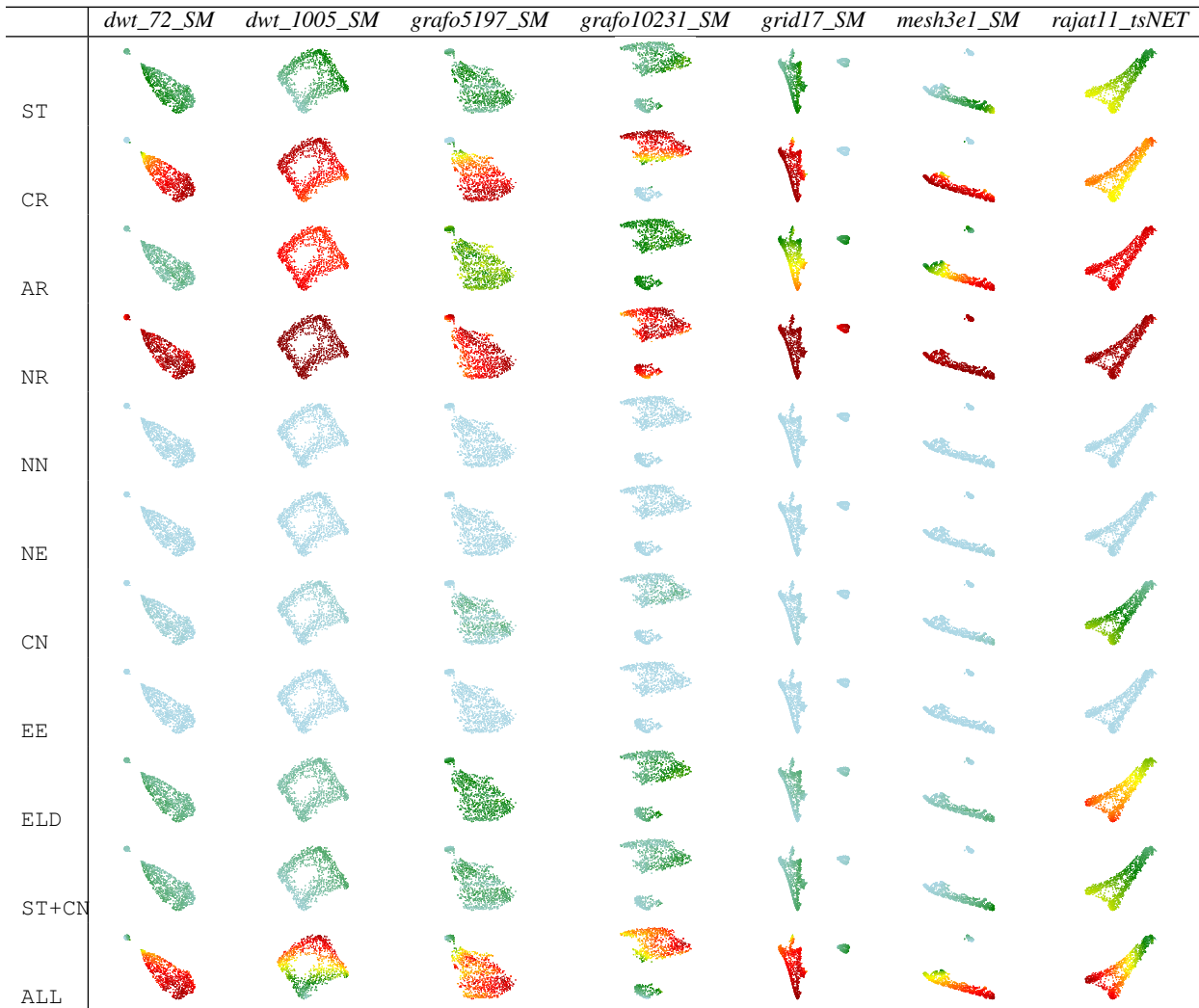


Figure 8: Projections of quality metrics of viewpoints for a few graph and layout technique combinations. Points are colored based on the normalized quality metric on the y-axis.

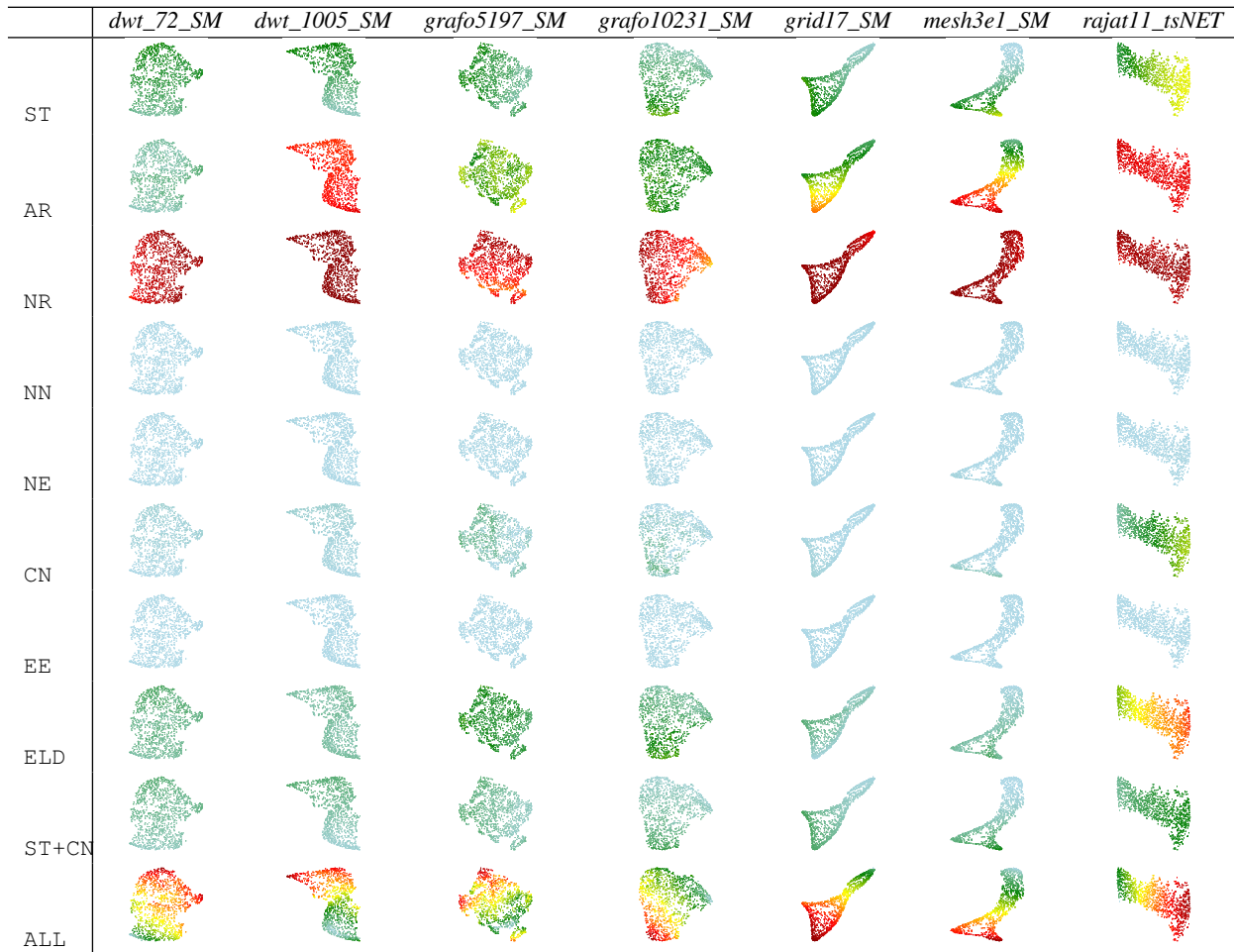


Figure 9: Projections of quality metrics of viewpoints for a few graph and layout technique combinations after the removal of the quality metric scores of CR. Points are colored based on the normalized quality metric on the x-axis.

3. Tool widgets

The other three widgets allow users to switch between metrics and techniques, to set weighted metric combinations, as well as provide information on the metric distributions and metric comparisons.

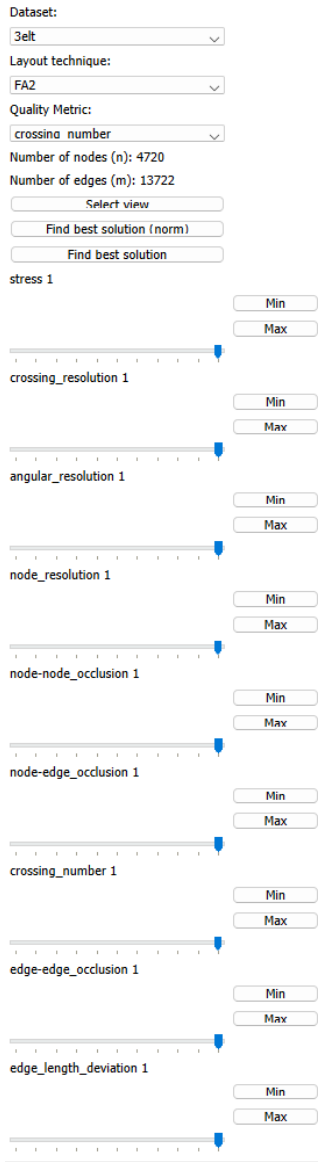


Figure 10: The visualized widget allows the user to switch between graphs, techniques, metrics, as well as set weighted metric combinations.

Viewpoint quality histogram

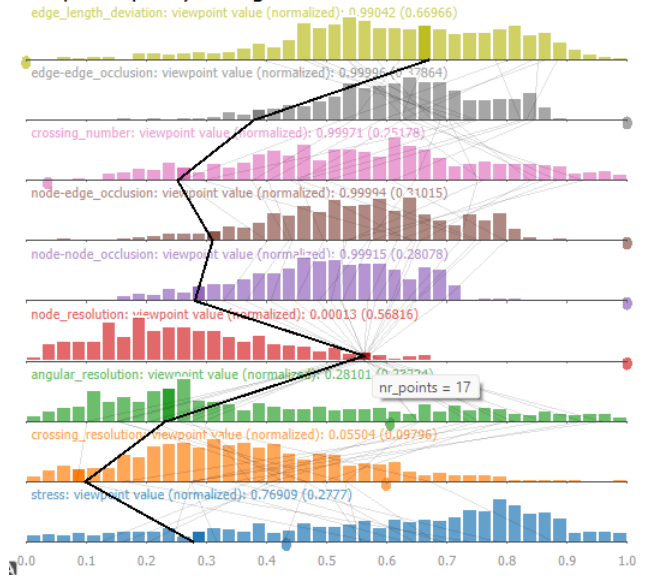


Figure 11: The visualized widget showcases normalized distributions of the nine quality metrics for all viewpoints. The linked line indicates a single viewpoint with its accompanying quality metric values.

edge_length_deviation	: 2d value 0.98844 best 3d value 0.99139 100.0% of viewpoints are better than 2d value best viewpoint is 0.003 better
edge-edge_occlusion	: 2d value 0.99999 best 3d value 0.99998 0.0% of viewpoints are better than 2d value best viewpoint is -0.0 better
crossing_number	: 2d value 0.99966 best 3d value 0.99989 99.9% of viewpoints are better than 2d value best viewpoint is 0.0 better
node-edge_occlusion	: 2d value 0.99997 best 3d value 0.99997 0.0% of viewpoints are better than 2d value best viewpoint is -0.0 better
node-node_occlusion	: 2d value 0.99969 best 3d value 0.99957 0.0% of viewpoints are better than 2d value best viewpoint is -0.0 better
node_resolution	: 2d value 0.00022 best 3d value 0.0002 0.0% of viewpoints are better than 2d value best viewpoint is -0.0 better
angular_resolution	: 2d value 0.34362 best 3d value 0.40966 25.6% of viewpoints are better than 2d value best viewpoint is 0.066 better
crossing_resolution	: 2d value 0.12393 best 3d value 0.17903 11.8% of viewpoints are better than 2d value best viewpoint is 0.055 better
stress	: 2d value 0.78218 best 3d value 0.83013 73.8% of viewpoints are better than 2d value best viewpoint is 0.048 better

Figure 12: The visualized widget supplies the user with clear information on the values of all quality metrics for the conventional 2D graph layout as well as the best values of the best viewpoint-layouts. Moreover, the percentage of viewpoints that score better than the conventional 2D layout is also given.

References

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