Exemplar-based Layout Fine-tuning for Node-link Diagrams (Supplemental Material)

Jiacheng Pan, Wei Chen, Xiaodong Zhao, Shuyue Zhou, Wei Zeng, Minfeng Zhu, Jian Chen, Siwei Fu, and Yingcai Wu

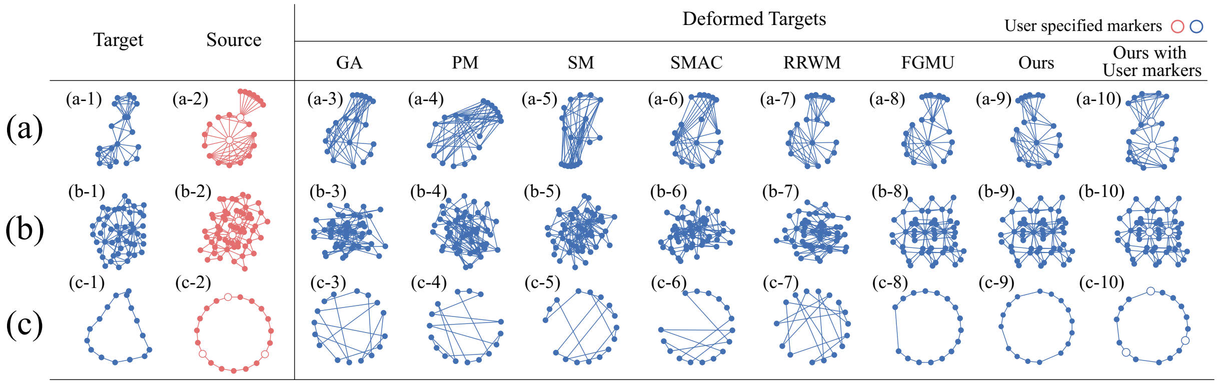


Figure 1. Comparison between our method and six automatic graph matching methods. Sources and targets are taken from (a) the Visualization-Publication dataset; (b) the Finan512 dataset; and (c) the Power-Network dataset. Targets are deformed into the shapes of sources with markers generated by GA, PM, SM, SMAC, RRWM, and FGMU (column 3 to 8). Our correspondences filtering algorithm selects a subset of correspondences generated by FGMU (column 9, ours). Targets can also be deformed into the shapes of sources with user-specified markers (column 10, ours with user markers).

Abstract—We describe details of our pre-study and the interface of our user study in this supplemental material

1 Pre-Study

Our modification transfer algorithm utilizes correspondences generated by graph-matching algorithms. We conducted a pre-study to inspect the correspondences. Any graph-matching method that produces injective correspondences is suitable for modification transfer. We only tested six graph matching algorithms with available implementation to verify the validity of our approach: GA (graduated assignment) [4], PM (probabilistic matching) [9], SM (spectral matching) [6], SMAC (spectral matching with affine constraints) [2], RRWM (re-weighted random walk matching) [1], and FGMU (factorized graph matching for undirected graphs) [10]. Three datasets are employed:

- The Visualization-Publication dataset [**?**] contains the papers that appeared at the IEEE VIS conference series from 1990-2018. We connected two authors if they co-authored in one paper to form a graph for each year. It generates 1,787 subgraphs with 9,677 nodes and 20,429 edges.
- The Finan512 dataset [8] is taken from the University of Florida Sparse Matrix Collection [3]. It is generated from the multistage stochastic financial modelling [8]. The graph consisted of 74,752 nodes and 261,120 edges.
- The Power-Network dataset [7] is collected from the Network Data Repository [7], which abstracts a power system. The nodes encode buses, and edges are the transmission lines among the nodes. The network consists of 662 nodes and 906 edges.

We laid out those graphs with FM^3 [5] and extracted two substructures (one source and one target) from each graph (Figure 1). We modified those source substructures into new layouts. We first transferred their modifications onto their corresponding target substructures with correspondences generated by six algorithms (Figure 1 (a-3) to (a-8), (b-3) to (b-8), and (c-3) to (c-8)). According to the quantitative comparative experiment conducted by Zhou et al. [10], FGMU can build more precise correspondences. Our pre-study verified that FGMU could generate layouts for targets that are more visually similar to sources because it builds more precise correspondences than the others. Thus, we choose FGMU to generate correspondences for modification transfer. However, in Figure 1 (c-8), we found one edge is much longer than other edges. Thus, we selected correspondences generated by FGMU using our correspondence filtering algorithm. Figure 1 (a-9), (b-9), and (c-9) are results generated by filtered correspondences. The shape of Figure 1 (c-9) is closer to Figure 1 (c-2). We also displayed the results generated by user-specified markers (Figure 1 (a-10), (b-10), and (c-10)). With several user-specified markers, our approach can also generate good results.

- *Jiacheng Pan, Xiaodong Zhao, Shuyue Zhou, Minfeng Zhu, Yingcai Wu, and Wei Chen are with the State Key Lab of CAD&CG, Zhejiang University, China. E-mail: {panjiacheng, zhaoxiaodong, zhoushuyue, minfeng_zhu, ycwu}@zju.edu.cn, chenwei@cad.zju.edu.cn. Yingcai Wu is also with Zhejiang Lab, China. Wei Chen and Yingcai Wu are the corresponding authors.*
- *Wei Zeng is with Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China. E-mail: wei.zeng@siat.ac.cn.*
- *Jian Chen is with Ohio State University, USA. E-mail: chen.8028@osu.edu.*
- *Siwei Fu is with Zhejiang Lab, China. E-mail: fusiwei339@gmail.com.*

Manuscript received xx xxx. 201x; accepted xx xxx. 201x. Date of Publication xx xxx. 201x; date of current version xx xxx. 201x. For information on obtaining reprints of this article, please send e-mail to: reprints@ieee.org. Digital Object Identifier: xx.xxxx/TVCG.201x.xxxxxxx

2 User Study Protocol

In this section, we list our training document (including the expert's instructions) we showed to the participants below:

Welcome, and thank you for participating in our study. You'll use three techniques (one manual technique, one semi-automatic technique, and one fully automatic technique) to help us fine-tune several structures' layouts. The study includes three parts: (1) training, (2) formal experiment, and (3) an interview. During the training session, we will show you a video about how to manipulate three techniques for fine-tuning. And you can operate the visual interface until you feel comfortable with the interactions and tasks. Please feel free to ask any questions.

Introduction. In the interface, you can see four parts: one title (Figure 2a), one exemplar (Figure 2b), one modified exemplar (Figure 2c), and one target structure (Figure 2d).

The title (Figure 2a) shows the serial number of datasets (e.g., "#1" represents the first dataset), the technique mode (e.g., "Semi-Automatic Mode" represents that you are manipulating the semi-automatic technique), and the progress of processing three structures in one dataset (e.g., "(1/3)" represents it is the first structure of all three structures).

Two red structures on the left are exemplars. The exemplar in the upper left (Figure 2b) is an origin layout. And the other in the lower left (Figure 2c) is the layout modified by an expert. They are the same, and only layouts are different between them. You should catch their difference, follow some instructions. And You need to manipulate the blue structure in the right, namely, the target structure (Figure 2d) to simulate modifications made on the exemplar.

Our system integrates three techniques:

1) when the title (Figure 2a) shows "Manual Mode", you need to use the mouse to drag nodes manually until you think the shape of the target (Figure 2d) simulates the modified exemplar (Figure 2c) well.

2) When it shows "Fully-Automatic Mode", you only need to click the "Apply" button in the bottom, our fully automatic technique will automatically compute a layout for the target that simulates the layout of the modified exemplar in the lower left (Figure 2c).

3) When it shows "Semi-Automatic Mode", you need to choose markers first. A pair of markers consists of one node in the exemplar (red) and one node in the target structure (blue). You can click one node in the target (it will be changed into a style with a white background and a blue stroke) and one node in the exemplar (it will be changed into a style with a white background and a red stroke) to select one pair of markers. For example, in Figure 2, two pairs of markers are chosen. A good pair of markers should be able to assume the same role or status in the exemplar and the target. After you finish marker selection, you need to click "Apply" button in the bottom. Steps after then are the same as "Fully-Automatic Mode".

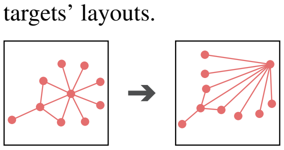
Note that, if you think layouts calculated by "Fully-Automatic Mode" and "Semi-Automatic Mode" are not satisfactory (e.g., it does not simulate the modifications made on the exemplar), you can also drag node manually for fine-tuning until you believe it simulates the modified exemplar well.

In our formal study, you have to process 36 trials. When you finish one trail, you can click the "Next" button.

Please feel free to ask questions during this training section. Please feel free to refer back to this presentation or the printout. Please complete each task as accurately and as quickly as you can. Accuracy is more important than speed.

After you complete these trials, we will interview you some question include your experience, feeling, and suggestions.

Instructions. We collected the instructions given by the expert when he modified exemplars' layouts. It may help you to manipulate targets' layouts.



1) The exemplar is modified into a fan-like shape. Nodes around the internal node with the highest degree should be placed around it within an angle.

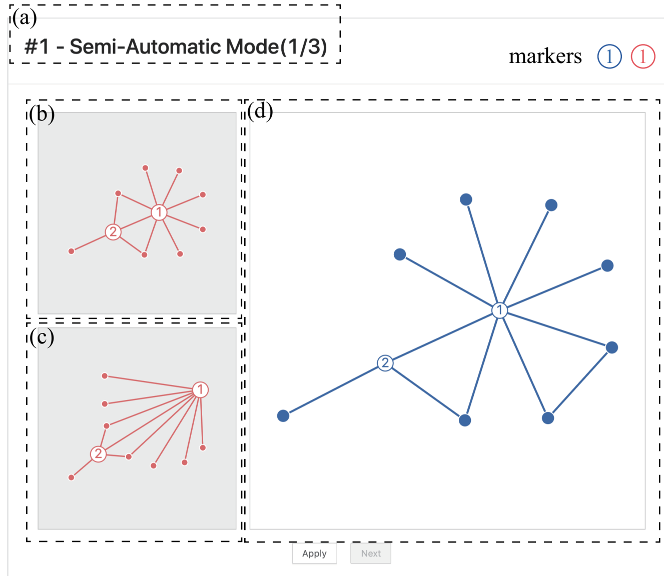
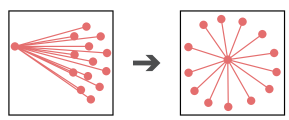
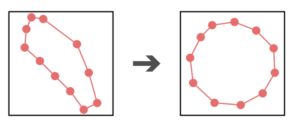


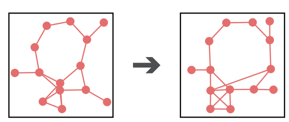
Figure 2. The user study interface: (a) the title; (b) the exemplar before expert modifications; (c) the exemplar after expert modifications; (d) the target substructure that participants can manipulate;



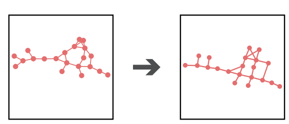
2) This exemplar is a star. After modification, the internal node with the highest degree should stay in the center, and the leaves are placed evenly around the internal node.



3) The exemplar is a cycle. It is modified into a circular. After modification, its shape should be as circular as possible.



4) The exemplar contains a circle and some surroundings nodes. The inner circle is laid out as a regular polygon, and the surrounding nodes are placed orthogonally.



5) It is modified into an orthogonal layout. The nodes should be placed in a grid-like shape. Angles among edges should be as close to 45°, 90°, or 180° as possible.

3 Results with Expert-Specified Markers

After the user study, the expert was invited to manipulate our semi-automatic method. We recorded several representative results in Figure 3.

References

[1] M. Cho, J. Lee, and K. M. Lee. Reweighted random walks for graph matching. In *Proceedings of European Conference on Computer Vision*, pp. 492–505, 2010.

[2] T. Cour, P. Srinivasan, and J. Shi. Balanced graph matching. In *Proceedings of Advances in Neural Information Processing Systems*, pp. 313–320, 2007.

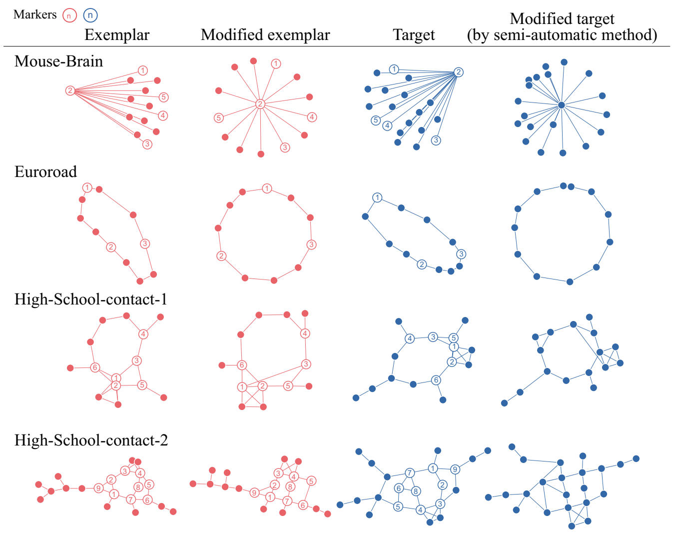


Figure 3. Results generated by our semi-automatic method with expert specified markers. Four datasets are listed in rows. Four columns represents: 1) exemplars, 2) exemplars after expert modification, 3) target substructures, and 4) target substructures generated by our semi-automatic method.

[3] T. A. Davis and Y. Hu. The university of Florida sparse matrix collection. *ACM Transactions on Mathematical Software*, 38(1), 2011.

[4] S. Gold and A. Rangarajan. A graduated assignment algorithm for graph matching. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 18(4):377–388, 1996. doi: 10.1109/34.491619

[5] S. Hachul and M. Jünger. Drawing large graphs with a potential-field-based multilevel algorithm. In *Proceedings of International Symposium on Graph Drawing*, pp. 285–295, 2004. doi: 10.1007/978-3-540-31843 -9
$_2$9

[6] M. Leordeanu and M. Hebert. A spectral technique for correspondence problems using pairwise constraints. In *Proceedings of IEEE International Conference on Computer Vision*, pp. 1482–1489, 2005.

[7] R. A. Rossi and N. K. Ahmed. The network data repository with interactive graph analytics and visualization. In *Proceedings of AAAI Conference on Artificial Intelligence*, pp. 4292–4293, 2015.

[8] A. J. Soper, C. Walshaw, and M. Cross. A combined evolutionary search and multilevel optimisation approach to graph-partitioning. *Journal of Global Optimization*, 29(2):225–241, 2004. doi: 10.1023/B:JOGO.0000042115.44455.f3

[9] R. Zass and A. Shashua. Probabilistic graph and hypergraph matching. In *Proceedings of IEEE Conference on Computer Vision and Pattern Recognition*, pp. 1–8, 2008. doi: 10.1109/CVPR.2008.4587500

[10] F. Zhou and F. De la Torre. Factorized graph matching. In *Proceedings of IEEE Conference on Computer Vision and Pattern Recognition*, pp. 127–134, 2012. doi: 10.1109/CVPR.2012.6247667