Effective Network Analytics: Network Visualization and Graph Data Management

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Network analytics provides a scientific solution to interact with networks through effective management of network data and corresponding visualization. Network analytics has been considered essential in many research areas as well as in commercial applications, including use cases in bioinformatics, biomedicine, security, social science, and knowledge graph exploration. We see that networks and the associated analysis process are expected to be initially supported by graph databases with advanced query engines, and later the filtered contents are rendered using corresponding visualization approaches for better communication and knowledge exchange. For this special issue (SI), we recruited papers describing research based on graph database utilization and network visualization that potentially could be integrated as a full pipeline, as well as their synergy for various applied problems. Through the formal *IEEE Computer Graphics and Applications* review process of the four submissions, we accepted three papers for this SI, focusing on the novelty and potential integration within the network analytics pipeline. These selected papers demonstrate the wide potentiality of techniques for complex network analytics.

Wen et al.[A1] developed a novel approach to visualize dynamic graphs, focusing on depicting the changes between each time step as a matrix. In contrast to classical techniques, which highly rely on users' mental workload to compare the temporal evolution of dynamic weighted graphs, *DiffSeer* explicitly shows the differences of graph structures, such as edge weight differences, between adjacent timeslices using a matrix representation. Multiple views have been integrated to inspect not only the graph overview but also the graph structure details in the timeslices of user interest. To achieve better exploration quality, an optimization on node order has been developed to group nodes with similar evolution patterns. Common interactions, including highlighting, are also implemented for emphasizing graph structure details in each timeslice. The technology allows us to untangle and explore temporal graphs in an effective manner.

Bipartite graphs are a common graph model, which describes the relationships between two disjoint sets of entities in various applications. Bipartite graphs are often drawn as two-layer graph drawings, where vertices are arranged on two parallel lines and edges are represented by segments connecting vertices. This classical drawing may cause edge-crossing problems when the relationship is dense. As studied in the article by Ahmed et al.,[A2] the authors introduced the concept of vertex splitting to reduce the number of edge crossings. This is done by replacing selected vertices on one layer with two (or more) copies and optimally distributing their incident edges among these copies. Several optimization problems relevant to this idea have been researched. Some problems have been demonstrated as NP-complete problems, and others are solved by the newly developed polynomial-time algorithms. Experiments on a benchmark set have been discussed. This article proposed a novel approach that is suitable for understanding bipartite graphs, which are often used in social science and biology.

As an applied topic, Tu et al.[A3] researched an interactive knowledge and learning environment in smart foodsheds. The main idea behind The Internet of Food (IoF) is to utilize a knowledge graph that integrates information about the environment, agriculture, food, diet, health, and so forth. However, due to the size and heterogeneity of the graph, it is challenging to retrieve information and explore the data interactively. The article presents a novel approach, interactive knowledge and learning environment (IKLE), which integrates three programming and modeling languages in order to support multiple downstream tasks in the pipeline. The contribution of the approach involves the development of the algorithm to automate the generation of the language, followed by a designed dataflow visualization system. Automatic

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language generations are organized as components, which allow users to construct the analysis pipeline systematically. Several real-world examples in smart foodsheds are shown to demonstrate the feasibility of the approach.

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APPENDIX: RELATED ARTICLES

A1. X. Wen et al., "*DiffSeer*: Difference-based dynamic weighted graph visualization," *IEEE Comput. Graphics Appl.*, vol. 43, no. 3, pp. 1–13, May/Jun. 2023, doi: 10.1109/MCG.2023.3248289.

A2. R. Ahmed et al., "Splitting vertices in 2-layer graph drawings," *IEEE Comput. Graphics Appl.*, vol. 43, no. 3, pp. 1–13, May/Jun. 2023, doi: 10.1109/MCG.2023.3264244.

A3. Y. Tu et al., "An interactive knowledge and learning environment in smart foodsheds," *IEEE Comput. Graphics Appl.*, vol. 43, no. 3, pp. 1–13, May/Jun. 2023, doi: 10.1109/MCG.2023.3263960.

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