AdMaTilE: Visualizing Event-Based Adjacency Matrices in a Multiple-Coordinated-Views System

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Abstract

Conventional dynamic networks represent network changes via a discrete sequence of timeslices, which usually entails loss of information on fine-grained dynamics. Recently, event-based networks emerged as an approach to model this temporal (event-based) information more precisely. Adjacency-matrix-based visualizations of temporal networks are under-investigated in related literature and present a promising research direction for network visualization. Our approach *AdMaTilE* (**Ad**jacency **Ma**trix and **Ti**mel**i**ne **E**xplorer) is designed to visualize event-based networks using multiple matrix views, timelines, difference maps, and staged transitions.

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Supplementary Material *Software (Source Code)*: `https://bitbucket.org/NikiHerl/admatile`

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1 Introduction

Dynamic graphs/networks extend the already versatile graph model with explicitly time-varying nodes, links, and/or attributes. Traditional dynamic network visualization [4] models graph dynamics as a sequence of states (i.e. timeslices) resulting in large memory requirements or loss of temporal information through aggregation. Event-based networks [7, 10] (i.e. temporal graphs) emerged as a solution to preserve these fine-grained changes, by recording the timestamps of individual graph events, i.e. (dis)appearances of nodes, links, or attributes. Current approaches to visualizing dynamic networks mostly utilize node-link diagrams to represent the graph's structure [4] and visualize the temporal information using juxtaposition, animation, and space-time cubes [1, 3, 10, 2]. Juxtaposition encodes the temporal dimension as discrete timeslices side by side, obscuring fine temporal details that may be crucial, such as in contact tracing networks. Animation, on the other hand, a more natural way to encode time, avoids such issues but has limitations in tasks involving a comparison of distant timeslices [5]. The event-based *space-time cube* $(2D + t)$ [10, 2] has been used for node-link diagrams/animations that capture finer details, particularly when many changes occur. Space-time-cubes have also been projected down to $2D$ [6], depicting node trajectories and guiding to interesting intervals ("when") or structures in the graph ("where"). Our research contributes to temporal graph drawing with an adjacency-matrix-based visualization of temporal networks, addressing some drawbacks of existing methods. Adjacency matrices provide an alternative representation of (dynamic) graphs, which, unlike node-link diagrams, doesn't suffer from (link-)overplotting as a graph's size and density grow. By integrating

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multiple matrix views with timelines, animation [9], difference maps [8], and animated staged transitions, our approach mitigates perceptual issues associated with animation and the information loss with juxtaposition.

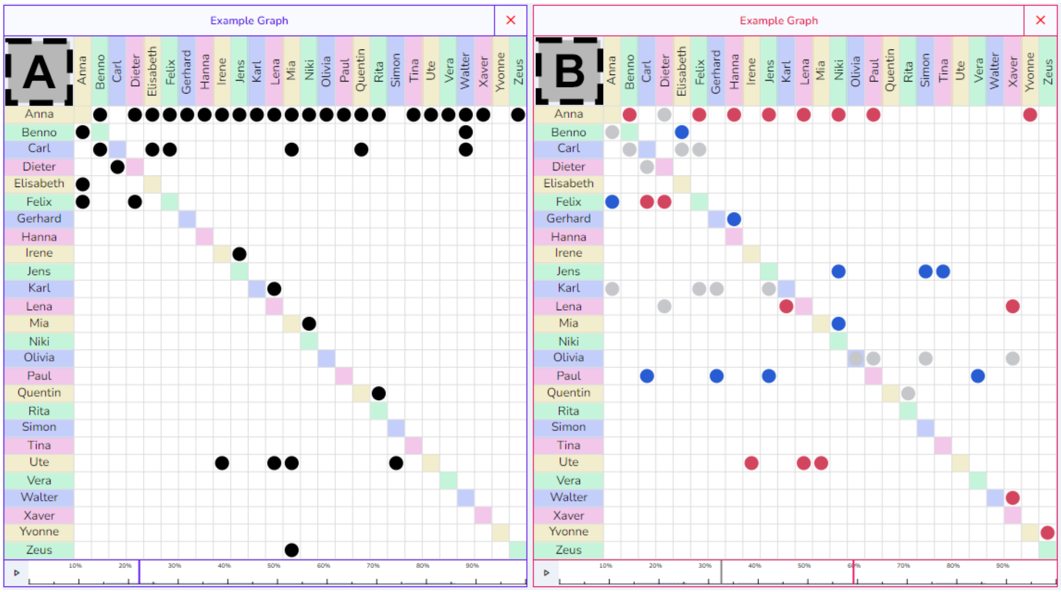

Figure 1 *AdMaTilE* displaying two juxtaposed views of the same temporal network. **(A)** Shows the state of the graph at a specific point in time. **(B)** A difference map between the primary selected time (red cursor on timeline) and the right-clicked time (grey cursor).

2 AdMaTilE

Our approach, *AdMaTilE*, available at admatile.web.app, parses dynamic (event-based) graphs encoded in the GEXF file format. These are visualized in interactive views that combine adjacency matrices, timelines, difference maps, and animated staged transitions. Multiple graphs and multiple views of each graph can be displayed simultaneously enabling a comparison of patterns between specific moments in time or between graphs using juxtaposition (small-multiples) approach (see Figure 1). The evolution of the graph can be observed through animation. Left-clicking the timeline and brushing enables analyst-driven navigation of the temporal dimension (see Figure 1-A).

Right-clicking on the timeline evokes one of two views: (i) a staged transition between the selected and the right-clicked point in time; or (ii) a difference map of the two timestamps. In a staged transition, first "removed" links are highlighted red and shrink away, then "added" links are highlighted blue and grow to full dots, indicating the emergence of new relationships. Difference maps display the same information instantly, with links either colored so as to emphasize changes (see Figure 1-B), or emphasizing unchanged links. The instant behavior allows brushing the timeline (holding the right-click) to search and identify particularly different (or similar) states of the graph in time.

To aid the identification of edges' source and target nodes, the node labels and their respective diagonal cells are colored in a cyclical color scheme. Furthermore, hovering over matrix cells displays a crosshair and highlights the source and target nodes.

References

1. Daniel Archambault, Helen Purchase, and Bruno Pinaud. Animation, Small Multiples, and the Effect of Mental Map Preservation in Dynamic Graphs . *IEEE Transactions on Visualization and Computer Graphics*, 2011. doi:10.1109/TVCG.2010.78.
2. Alessio Arleo, Silvia Miksch, and Daniel Archambault. Event-based Dynamic Graph Drawing without the Agonizing Pain. *Computer Graphics Forum*, 41(6):226–244, 2022. doi:10.1111/cgf.14615.
3. Benjamin Bach, Emmanuel Pietriga, and Jean-Daniel Fekete. Visualizing Dynamic Networks with Matrix Cubes. In *Proc. of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '14, pages 877–886. Association for Computing Machinery, 2014. doi:10.1145/2556288.2557010.
4. Fabian Beck, Michael Burch, Stephan Diehl, and Daniel Weiskopf. A Taxonomy and Survey of Dynamic Graph Visualization. *Computer Graphics Forum*, 36(1):133–159, 2017. doi:10.1111/cgf.12791.
5. Velitchko Filipov, Alessio Arleo, Markus Bögl, and Silvia Miksch. On Network Structural and Temporal Encodings: A Space and Time Odyssey. *IEEE Transactions on Visualization and Computer Graphics*, 2023. doi:10.1109/TVCG.2023.3310019.
6. Velitchko Filipov, Davide Ceneda, Daniel Archambault, and Alessio Arleo. TimeLighting: Guidance-Enhanced Exploration of 2D Projections of Temporal Graphs. In *Graph Drawing and Network Visualization (GD '23)*, pages 231–245. Springer, 2024. doi:10.1007/978-3-031-49272-3_16.
7. Petter Holme and Jari Saramäki. Temporal Networks. *Physics Reports*, 519(3):97–125, 2012. doi:10.1007/978-3-642-36461-7.
8. Sébastien Rufiange and Michael J McGuffin. DiffAni: Visualizing Dynamic Graphs with a Hybrid of Difference Maps and Animation . *IEEE Transactions on Visualization and Computer Graphics*, 19(12):2556–2565, 2013. doi:10.1109/TVCG.2013.149.
9. Sébastien Rufiange and Guy Melançon. Animatrix: A Matrix-based Visualization of Software Evolution. In *2014 second IEEE working conference on software visualization*, pages 137–146, 2014. doi:10.1109/VISSOFT.2014.30.
10. Paolo Simonetto, Daniel Archambault, and Stephen Kobourov. Event-based Dynamic Graph Visualisation. *IEEE Transactions on Visualization and Computer Graphics*, 26(7):2373–2386, 2018. doi:10.1109/TVCG.2018.2886901.