ThreadWave: Visualizing Co-authorship as Temporal Threads

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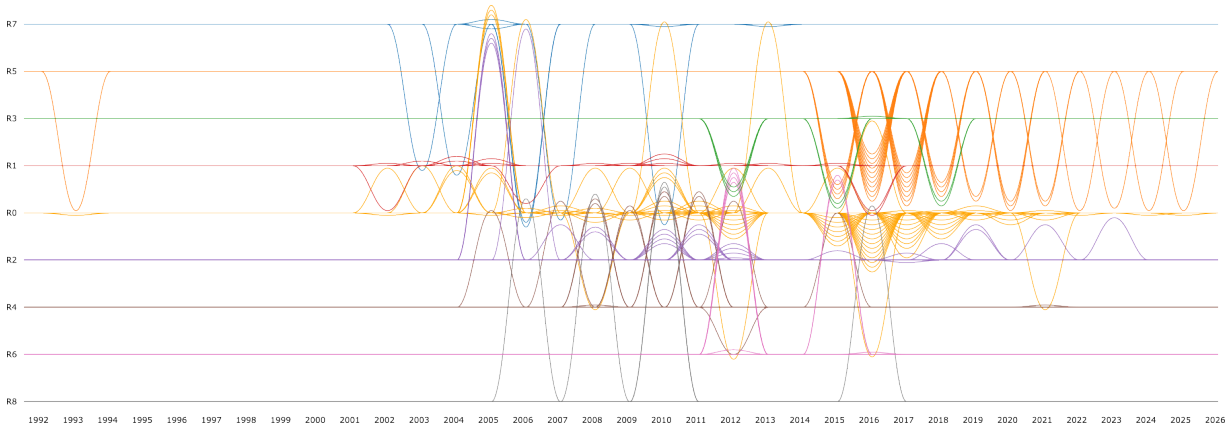

Figure 1: ThreadWave visualization depicting the temporal and relational dynamics of researcher R0's collaborations. The X-axis represents time, while the Y-axis lists nine researchers (R0–R8), each assigned a distinct color. Curved lines (i.e., waves) illustrate co-authorship events, revealing when and with whom R0 collaborated over their research journey.

Abstract

We present a timeline-based visualization for exploring temporal collaboration patterns among academic authors. Inspired by the metaphors of weaving threads and ripple waves, our technique represents each author as a colored baseline and uses curved connectors to show co-authorship events over time.

Index Terms: Collaboration, data visualization, collaboration analysis, temporal visualization, digital humanities.

1 Introduction

Academic collaboration patterns are most commonly visualized using network graphs or dashboards that indicate *who has collaborated with whom*, but they often fail to convey *when* these collaborations took place. Bibliometric tools such as VOSviewer[9][1], Gephi[1][2], and the Social Network app for Cytoscape[7][3] automatically construct co-authorship networks by representing researchers as nodes and linking them with edges if they have co-authored publications. Such visualizations depict overall connectivity and can encode collaboration intensity, e.g., by using node size or edge thickness to encode the number of joint publications[4], and clustering tightly connected authors into groups [6]. While effective for showing aggregate relationships, one can see who collaborated, but not the narrative of when and how those relationships formed over the years.

Time is a crucial element in understanding the story behind collaborations. In storytelling, we often rely on temporal cues ("Once upon a time... then...") to give context and meaning. Likewise, an academic's collaboration history can be viewed as a timeline: partnerships begin, evolve, and sometimes fade. However, traditional co-authorship graphs and dashboards offer limited support for exploring temporal evolution. At best, viewers might filter the network by year or range, or examine a series of snapshot graphs, to infer how collaborations change over time. This approach is cumbersome and disrupts continuity – filtering to different time slices means losing the previous context, making it hard to follow long-term trends or identify sequential events.

To address this gap, we propose a timeline-based visualization technique that integrates time and collaborative patterns. We draw inspiration from narrative visualization metaphors: for instance, storyline visualization methods in information visualization represent each character as a line that flows along a time axis, with lines converging when characters interact [5]. This metaphor has been used to illustrate dynamic relationships in stories and history (e.g. Randall Munroe's famous movie narrative charts, or more recent systems like iStoryline [8] which helps craft such story timelines. Even in popular culture, simple line-based illustrations have captured relationship dynamics, take Olivia de Recat's "Closeness Lines" cartoon [2] for example, which depicts how personal relationships strengthen or weaken over time using lines that draw together or apart. As Paul Klee famously said, "a line is a dot that went for a walk," emphasizing the dynamic, journey-like quality a line can convey [3].

Guided by these ideas, we reimagine co-authorship data in a static temporal form: each author is visualized as a distinct line progressing through time, and collaboration events become connections between these lines. The design enables intuitive visual analysis of influence, co-authorship dynamics, and collaboration intensity.

2 ThreadWave

Each author has a color and a baseline, which is straight for the time span when there is no collaboration. The intention was to explore collaborations with small-sized groups of academic collaborators, using evidence of collaborations based on publications.

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[1] https://www.vosviewer.com/
[2] https://gephi.org/
[3] https://cytoscape.org/

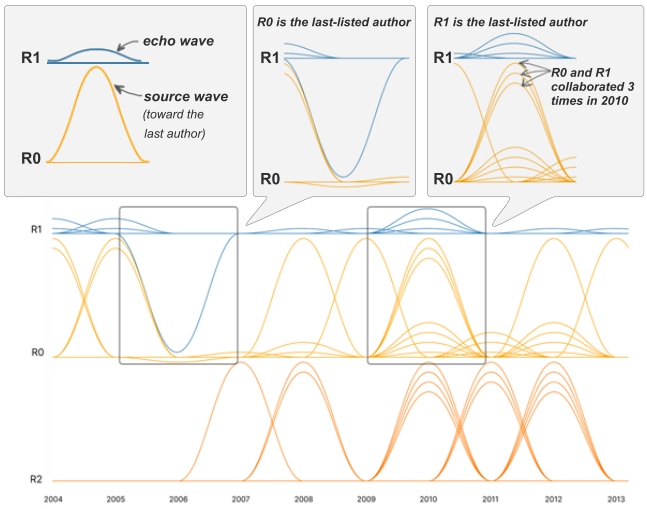

Figure 2: Visual encoding in ThreadWave: The tall source wave curves toward the last author's track. Overlapping ripples represent multiple co-authorships occurring in the same year.

When a collaboration occurs, a smooth Bézier curve (i.e., *source wave*) is drawn from each contributing author's baseline toward the last author's track. In this example (Figure 2), the last author (R0) is positioned at the vertical center, guiding the direction and curvature of the connections. Each contributing author's track features a smaller *echo wave*, visually reflecting their participation in the collaboration with the last author. This layered design metaphorically suggests the ripple effect of academic influence.

When multiple collaborations occur in the same year, they are rendered as overlapping ripples with slight vertical offsets to maintain readability. These visual cues support a rapid view of *when*, *with whom*, and *how frequently* researchers (e.g., R1, R2) collaborated with R0 between 2004 and 2013. Following a single author's connections over time reveals frequent collaborators, where ripples repeatedly converge on the same track, and highlights shifts in collaborative patterns.

3 Exposition

We formalise the branch construction and dynamic-offset procedure used to visualise collaboration events on a multi-polyline timeline.

Timeline grid and author tracks. The visualisation is drawn on a discrete temporal grid $\mathcal{T} = \{t_0, \ldots, t_{n-1}\}$ that enumerates the years 1993–2025. Each author is assigned a horizontal baseline track $L_i = \langle y_{i,0}, \ldots, y_{i,n-1} \rangle$ where $y_{i,k}$ denotes the *vertical* position of author i in year t_k. The constant spacing h between successive baselines yields a clear, regular layout that can be recomputed after dynamic editing.

Connector construction (U-shape return). For a collaboration record $\langle t_k, a_0, \ldots, a_{r-1} \rangle$ we designate the last author $a^\star = a_{r-1}$ as the *pivot*. For every contributing author a_j we create a sparse poly-line that (i) originates on a_j's baseline at t_k, (ii) dives to the pivot baseline $y_{a^\star,k}$ at the temporal midpoint $t_k + \frac{1}{2}$, and (iii) resurfaces on a_j's baseline at t_{k+1}. The baseline ordinates that would otherwise duplicate this path are set to `null` so that each straight segment is rendered *once and only once*.

Dynamic fan-out. Multiple connectors may converge on the same pivot in the same year, producing visual stacking. Let g be the number of such connectors; we order them $0, \ldots, g-1$ and apply a small, symmetric vertical offset only at their midpoint point:

$$\delta(j) = \left(j - \frac{g-1}{2} \right) \eta, \quad \eta = 0.08h. \tag{1}$$

Equation 1 creates a compact ribbon whose amplitude is proportional to the baseline spacing, an approach adapted from local edge-bundling techniques that improve readability in dense graphs.

Rendering. Successive defined vertices are joined with cubic Bézier segments whose control points are placed at $0.4\Delta x$ from each end (Δx is the year-to-year horizontal spacing). This fixed-ratio rule gives C^1 continuous tangents without over-accentuated curvature and requires no per-branch parameter tuning.

4 Conclusion and Future work

We introduce a static visualization technique that weaves timelines and collaboration patterns into a unified, narrative-driven view of academic co-authorship. Inspired by the visual metaphor of threads and waves, our design reflects the flow of collaboration and mutual influence among researchers, where each connection generates ripples of academic interaction. By combining aesthetic principles with temporal encoding, the visualization reveals who, when, and how those relationships evolved over time.

Future work will focus on scaling the visualization to larger collaboration networks, integrating metadata such as research topics and publication venues, and adding interactive features for filtering and exploration. We also aim to explore the adaptation of the technique to other domains where temporal relationships matter, such as team dynamics or creative collaborations, and evaluate its effectiveness in supporting interpretation and sensemaking compared to traditional network graphs.

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