Visualizing Tennis Matches as Nested Stories

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2023 27th International Conference Information Visualisation (IV) | 979-8-3503-4161-4/23/$31.00 ©2023 IEEE | DOI: 10.1109/IV60283.2023.00025

***Abstract*—This work is about data-driven storytelling in tennis. Tennis has a peculiar scoring system that makes it challenging for the general audience to understand tennis matches. But from a storytelling perspective, the tennis scoring system has unique benefits because it creates a nested story structure. Dividing a tennis match into sets and games helps manage the tempo and rhythm of a story while creating suspense on multiple levels. The ad-scoring rule helps prolong the struggle, delay the outcome, and create suspense. However, the traditional sports news media has failed to present tennis matches as nested stories, and the suspense is often lost in the news report and match highlight videos.**

In this paper, we describe a novel visualization method to present tennis matches as nested stories. This visualization can help readers better understand the narratives of tennis matches without the barriers of the scoring system and the written language. In essence, this is a universal visual language that presents the stories of tennis matches in an intuitive way. Such visualizations can supplement the traditional textual and video coverage of tennis matches. It can also be applied to other sports with similar nested story structures. Our preliminary user studies showed highly positive user first impressions.

***Index Terms*—data visualization, storytelling, sports**

I. Introduction

Data-driven storytelling [1] has been gaining momentum in recent years. Our work focuses on data-driven storytelling in sports, specifically tennis. Tennis is one of the most popular racket sports. But it also has one of the most peculiar scoring systems [2]. A tennis match is divided into sets and sets into games. Each game is scored in a non-linear point system with a mixture of numbers and words. The tennis tiebreak rules have been complicated and inconsistent until recently. Part of tennis' appeal is its long history, and the unusual scoring system is one of its long-lasting traditions. Some rules and terms in the tennis scoring system date back hundreds of years.

But the eccentric scoring system creates a barrier for people, particularly young children, to play, understand, and enjoy tennis. Rather than helping spectators overcome this barrier, the traditional news reports of tennis matches generally sidestep the scoring system, showing only the final score, describing several key moments, and quoting a few lines from the players. The popular match highlight videos show entertaining shots and rallies but do not tell accurate and coherent stories about the matches.

From a storytelling perspective, the tennis scoring system is an interesting narrative device with unique benefits. The tennis scoring system gives a tennis match a nested story structure [3], [4]. Each set is a story embedded in a match, and each game is a story embedded in a set. Dividing a tennis match into sets and games helps create and manage the story's tempo and rhythm while creating suspense on multiple levels. The ad-scoring rule helps prolong the struggle and delay the outcome, thus maintaining suspense. Many elements of entertaining sports stories, such as suspense, dramatic comeback, narrow escape, and missed opportunities, are inherently encoded in the tennis score system. However, these story elements are generally lost in sports data analytics and visualization. We need a new media presentation that lets viewers quickly read a tennis match as a story with medium-level details.

In this paper, we present a novel, web-based, interactive tennis match visualization technique. We embrace the tennis scoring system as a storytelling device that shows a tennis match as a nested story. It gives readers a complete picture of a tennis match, providing more details than traditional sports news reports and match highlight videos. The data visualizations are intuitive and self-explanatory so that people from different language backgrounds can easily understand the stories. Compared to many other sports data visualizations, we do not overwhelm readers with low-level tactical or statistical data. Casual readers with only passing knowledge of tennis scoring rules can understand our data visualization.

Furthermore, readers can quickly identify interesting sports story elements such as seesaw battles, dramatic comebacks, perseverance, narrow escapes, and missed opportunities. The suspense of following live tennis matches is also conveyed in our visualization, which can be used as a live tennis broadcasting tool or as a supplement to traditional sports news reports and match highlight videos. We have conducted a small user study that showed highly positive user first impressions.

The data visualization techniques discussed in this paper can be readily adapted for other sports with similar scoring systems, such as pickle ball, table tennis, badminton, volleyball, beach volleyball, etc.

II. Related Work

Coverage of professional tennis matches can be classified into four categories: score-only, text, visualization, and video. It can be further divided into live and post-match coverage. Table I shows different methods for covering professional tennis matches.

2375-0138/23/$31.00 ©2023 IEEE
DOI 10.1109/IV60283.2023.00025

	Live	Post-match
Score-only	Score broadcasting	Archived match results
Text	Blogging; social media	News reports
Visualization	Data visualization	Data visualization
Video	TV broadcasting; streaming	highlight videos; full-match videos

TABLE I: Different media format for covering pro tennis matches

Our proposed method falls into the category of data visualization, and it can be used for visualizing live tennis matches or finished ones. The closest comparable work is MatchBeats [5], a live tennis match visualization developed by InfoSys for the Australian Open tennis championship tournament. However, there are significant differences between our method and MatchBeats. First, MatchBeats displays the tennis tactical data such as rally length, serve speed, winners, unforced errors, aces, double faults, breakpoints, etc. It is designed for people interested in the tactical details of tennis matches. Our visualization focuses on telling the overall stories of tennis matches rather than the tactical details. We target casual viewers who want to quickly understand how the match is played out. Second, MatchBeats focuses on low-level details without an overview of the match. Our visualization focuses on the medium-level details, with a clear overview of the match. Third, MatchBeats is a variation of a bar chart, while our visualization is a multi-view line plot. The Australian Open website also features statistical visualizations such as Rally Analysis, Stroke Summary, and CourtVision, but they are less relevant to our work.

Sports data visualization [6], [7] is an emerging sub-field of data visualization research. Many visualization techniques have been developed for various sports [8]–[20], including tennis [21]–[29] and other racket sports such as table tennis [30]–[34] and badminton [27], [29]. Our method fundamentally differs from the other sports data visualization techniques because our method focuses primarily on visual storytelling [35]–[38] while most other sports data visualizations focus on visual analytics. For example, TenniVis [22] features a complicated visual interface that includes custom pie meters and bar charts showing detailed tactical and statistical information such as winners, forced errors, unforced errors, aces, double faults, winning probabilities, etc. TacticFlow [29] also features a complex visualization comprising five views: Control Bar, Flow View, Tactic View, Projection View, and Rally View. Our previous work, Tactical Rings [25], uses segmented concentric rings for analyzing shot-by-shot tactical patterns in tennis. These visualizations are designed for deep tactical analysis by players, coaches, sports analysts, or knowledgeable tennis fans. Their user interfaces are complicated, and casual users will feel overwhelmed by the complexity of multivariate data visualization.

Our visualization is designed for casual browsing and quick comprehension. We do not focus on a player's individual performance or overload viewers with statistical and low-level tactical details. Instead, we focus on high-level storytelling that clearly shows the struggle between two players, the twists and turns, the reversals and comebacks, the missed opportunities, the suspense, and the player's mental strength. We want to present a tennis match in a condensed visual form so that viewers can get the drama of a three-hour tennis match in less than 30 seconds.

III. Visualization Design

A. Tennis Scoring System and Nested Stories

The tennis scoring system has a complicated history, and the rules have been adjusted over the years. There is no universal scoring system in tennis. Different tennis organizations or tournaments may adopt different rules. Here we will describe the most commonly used scoring system at the professional level. The reason for describing the scoring system is that it dictates the structure of our visualization.

A tennis match is divided into sets. Most tournaments use the best-of-three sets, but the men's grand slam tournaments (Australian Open, French Open, Wimbledon, and US Open) use best-of-five sets. Each set consists of multiple games. If a player wins six games before the opponent wins five games, the player wins the set. If both players win five games each, then a player needs to win two consecutive games to win the set. If both players win six games each, then a tiebreak game is played to decide the set winner.

For a non-tiebreak game, the score calling is a mixture of numbers and words: "love", 15, 30, 40, and "game". The game-winning point is called "game". If the score is tied at 40-40, it is called a "deuce", and a player needs to win two consecutive points to win the game. Each time a player wins a point after a deuce, it is called "advantage" (or "ad"). If the score is tied again after an "advantage", it is back to "deuce," and so on.

Tiebreak games use straightforward numerical scoring. If a player wins a point, the player's tiebreak score increases by one. To win a set tiebreak game, a player must reach seven points before the opponent reaches six points. If the score is tied at six points each, then a player needs to win two consecutive points to win the game. In some tournaments, to win a match tiebreak game, a player must reach ten points before the opponent reaches nine points. If the score is tied at nine points each, then a player needs to win two consecutive points to win the match.

From a storytelling perspective, the peculiar tennis scoring system is an interesting device that helps construct the narrative of a tennis match. The match-set-game hierarchy creates a nested story structure. The nested story is a literary device where a story is embedded in another story [3], [4]. Therefore, nested stories are also called "embedded narratives" or "stories within stories." One example of a nested story is the 2010 movie Inception. A tennis match has three layers of stories: match, set, and game. Each game is a story embedded in a set

story, which is then embedded in the match story. Each story has its beginning, middle, and climax. Each story has its own twists and suspense.

The tennis scoring system is quite effective for creating and managing suspense. Three layers of stories create three layers of suspense: who will win this match? Who will win this set? Who will win this game? Because the outcome of each game affects the probability of winning the set, the multiple layers of suspense are intertwined, which keeps the audience engaged. The best-of-three set rule in grand slam tournaments creates longer suspense and more opportunities for comebacks. Furthermore, the rule of advantage-scoring (i.e., a player has to win two consecutive points after a Deuce to win a game) can potentially prolong the struggle and keep the audience on edge for a longer period. (The NCAA College Tennis in the United States has adopted a no-advantage-scoring rule to speed up the matches, but these games are less suspenseful.)

The match-set-game hierarchy also helps define the tempo and rhythm of the story. A three-set match is like a three-act story, and a five-set match is like a five-act story. The end of each game or set brings some closure and lets the audience take a breath before the tension rises again.

Overall, the tennis scoring system creates a relatively complex story structure that keeps the audience engaged. Perhaps this is one of the reasons this scoring system has survived for such a long time. The traditional news reports and match highlights have sidestepped the scoring system, thus missing the opportunity to present tennis matches as intricate stories with multiple layers of suspense. Our work is an attempt to address this issue.

B. Data

Our data visualization is based on live or archived match score data from tennislive.net [39]. This website broadcasts live tennis scores from many professional tournaments. It also stores older tennis scores, rankings, and statistics for professional players.

C. Layout

Figure 5 shows an example of our data visualization. Each row represents a set. The first line chart (with a gray background and blue frame) on each row shows the game scores for a set. After that, each line chart (with a light green background) shows the point score for each game. Each line represents a player's point score, and line colors differentiate the players. We adopt a minimalist design with as few labels as possible, thus minimizing the language barrier. The visualization design is intuitive and self-explanatory so that people with only a passing knowledge of tennis can understand it with little to no instructions. This is one of the main differences between our visualization and other sports data visualizations, which often try to pack as much information as possible into a chart.

Our visualization is web-based and interactive. The landing page of our website asks users to select live or finished tournaments and then select a tournament and a match (Figure 1).

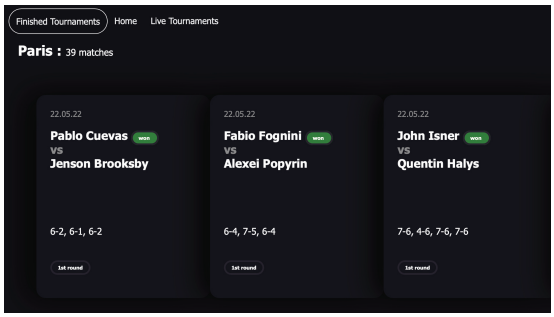


Fig. 1: Selecting matches to visualize

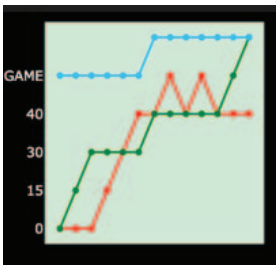


Fig. 2: Game score visualization. The red player missed three opportunities. The green player narrowly escaped defeat.

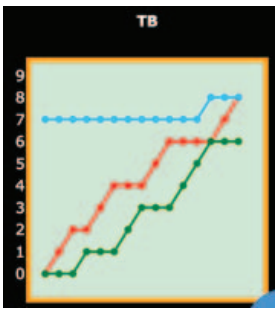


Fig. 3: Tiebreak game visualization. The green player fought back near the end but still lost.

D. Game Visualization

The set score visualization is straightforward because it is simple linear numerical scoring. The game score visualization (Figure 2) is also quite easy to understand. The red and green lines represent the point scores for each player. The blue line represents the target point score each player is trying to reach. Whoever reaches the target blue line first wins the game. Therefore, the visualization shows how close each player is to winning the game. In Figure 2, the red line goes up, down, up, and down because the score goes from deuce to advantage, to deuce, to advantage, and then to deuce again. This visualization shows the green player led early, but the red player came back to take the lead. Then the red player came close to winning the game three times but eventually lost it, a real disappointment for the player. On the other hand, the green player held his nerve and seized the first chance to win the game. This game is a hard-fought battle with two reversals. Our visualization conveys this entertaining story without using a word.

E. Tiebreak Game Visualization

Figure 3 shows a tiebreak game. Again the blue line is the target point score that both players tried to reach. The red player led all the way and wasted three chances to win the game, but finally took the last one. The green player saved

three set points and tied the game but unfortunately lost it soon after. It is another thrilling game.

F. Visualizing Narrative Elements

The goal of our visualization is to tell sports stories with clarity and efficiency. Entertaining sports stories that capture the drama and excitement of a sports event often share some common elements: suspense, dramatic comebacks, near escapes, bitter disappointments, etc. Although our visualization cannot present all elements of sports stories, it can convey some narrative elements clearly and intuitively. Here are some examples.

- **Uncertainty and suspense**. An entertaining sports story is usually full of suspense that keeps viewers on the edge of their seats. Close score and seesaw battle create uncertainty, and an extended period of uncertainty creates suspense. In our visualization, readers can quickly identify periods of close score and seesaw battle in a tennis match, particularly in live tennis match visualization. Please see Figure 4a.
- **Comebacks**. Comebacks are a common theme in many entertaining sports stories. In our visualization, comebacks are easy to identify because the score lines form a closed polygon. Please see Figure 3 and Figure 4b.
- **Perseverance**. Sports spectators admire a player's mental toughness and perseverance, regardless of the outcome. In our visualization, readers can appreciate a player's perseverance through the player's repeated attempts to win or save a game. Please see Figure 4c.
- **Narrow escape**. Perhaps nothing is more exciting than watching your favorite player escape an almost certain defeat. Readers can easily identify near escapes in our visualization. Please see Figure 2 and Figure 4d.
- **Missed opportunity**. Missed opportunities are the opposite side of narrow escapes. A missed opportunity creates disappointment and anger. The prospect of disappointment creates fear, which enhances the suspense. Missed opportunities are easy to spot in our visualization: readers can quickly see when a player was very close to victory but eventually lost. Please see Figure 2 and Figure 4d .

Of course, some sports story elements are beyond the capability of our data visualization. Our visualization cannot tell the story of historical rivalries, an underdog defeating the favorite, a player overcoming injury or illness, or the significance of the match. Traditional news reports are better at covering these elements. But our visualization can be an effective supplement to the traditional media.

G. Implementation

We implemented our program in Python. The program retrieves live or finished match scores from tennislive.net [39]. The local data is stored in Elasticsearch. The data visualization is created with Plotly.

IV. User Study

In the spring of 2023, we conducted a small user study with seven subjects (four males and three females). The subjects were college students aged between 20 to 30. Four were familiar with tennis rules, one had only passing knowledge, and two were unfamiliar with tennis rules. We gave the subject a very brief introduction, telling them this was a data visualization program to show the progress of tennis matches. We then let the subjects explore data visualization independently without our supervision or intervention. Our goal was to get their first impressions and feedback.

The subjects entered their feedback anonymously on a Google Form. We asked them to rate the program from 1 to 5 (with 5 being the best) and write comments. The average user rating was 4.71. The subjects liked the simple user interface and how quickly they could understand a long match. Some users pointed out it would be helpful to pair this program with a program that provides more in-depth statistics and player profiles so that a user can dig deeper into the data analysis if necessary.

V. Conclusion and Future Work

We have described a novel data visualization method for presenting an entire tennis match in a compact visual form. The visualization provides a quick read of a tennis match with medium-level details and a nested story structure. Our preliminary user studies showed that the users' first impressions were highly positive.

We are working to improve our data visualization to make it even more user-friendly and intuitive. If our data visualization is synchronized with full-match videos, which is technically feasible, readers can quickly find the most entertaining parts of the match to watch. We will also explore the possibility of applying this type of visualization to sports with similar scoring systems, such as pickleball, table tennis, badminton, or volleyball.

References

[1] N. H. Riche, C. Hurter, N. Diakopoulos, and S. Carpendale, Eds., *Data-driven storytelling*. CRC Press/Taylor & Francis, 2018.

[2] M. Fabry, "Why is tennis scored so weirdly?" *Time*, August 2019, Last accessed on 2023-04-28. [Online]. Available: https://time.com/5040182/tennis-scoring-system-history/

[3] D. Herman, M. Jahn, and M.-L. Ryan, Eds., *Routledge encyclopedia of narrative theory*. Routledge, 2010.

[4] D. Lodge, *The art of fiction: illustrated from classic and modern texts*. Penguin books, 1992.

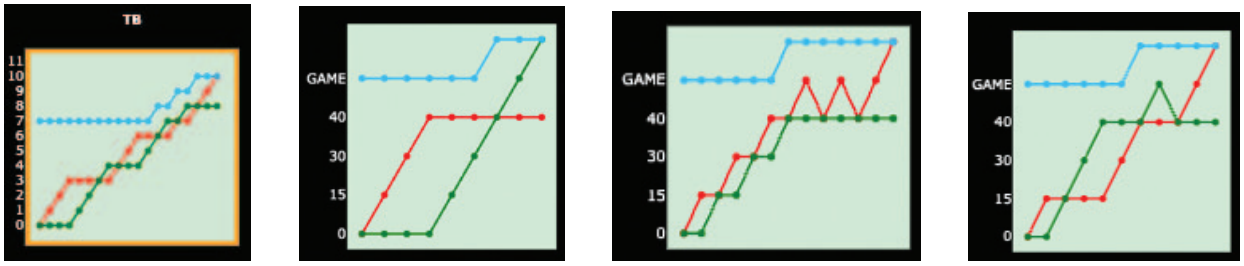
[5] "Australian Open Tennis Championship," https://ausopen.com/results, Last accessed on 2023-04-28.

[6] C. Perin, R. Vuillemot, C. D. Stolper, J. T. Stasko, J. Wood, and S. Carpendale, "State of the art of sports data visualization," *Computer Graphics Forum*, vol. 37, pp. 663–686, 2018.

[7] M. Du and X. Yuan, "A survey of competitive sports data visualization and visual analysis," *Journal of Visualization*, vol. 24, pp. 47–67, 2021.

[8] B. Bowman, N. Elmqvist, and T. J. Jankun-Kelly, "Toward visualization for games: Theory, design space, and patterns," *IEEE Transactions on Visualization and Computer Graphics*, vol. 18, pp. 1956–1968, 2012.

[9] H. Pileggi, C. D. Stolper, J. M. Boyle, and J. T. Stasko, "Snapshot: visualization to propel ice hockey analytics," *IEEE Transactions on Visualization and Computer Graphics*, vol. 18, pp. 2819–2828, 2012.



(a) A seesaw battle (b) Green player's comeback (c) Red player's perseverance (d) Red player's narrow escape

Fig. 4: Typical sports story elements

[10] M. Lage, J. P. Ono, D. Cervone, J. Chiang, C. Dietrich, and C. T. Silva, "Statcast dashboard: exploration of spatiotemporal baseball data," *IEEE Computer Graphics and Applications*, vol. 36, pp. 28–37, 2016.

[11] C. Perin, R. Vuillemot, and J. D. Fekete, "Soccerstories: A kick-off for visual soccer analysis," *IEEE Transactions on Visualization and Computer Graphics*, vol. 19, pp. 2506–2515, 2013.

[12] C. Perin, J. Boy, and F. Vernier, "Using gap charts to visualize the temporal evolution of ranks and scores," *IEEE Computer Graphics and Applications*, vol. 36, pp. 38–49, 2016.

[13] W. Chen, T. Lao, J. Xia, X. Huang, B. Zhu, W. Hu, and H. Guan, "Gameflow: Narrative visualization of NBA basketball games," *IEEE Transactions on Multimedia*, vol. 18, pp. 2247–2256, 2016.

[14] A. G. Losada, R. Theron, and A. Benito, "Bkviz: A basketball visual analysis tool," *IEEE Computer Graphics and Applications*, vol. 36, pp. 58–68, 2016.

[15] Q. Zhi and R. Metoyer, "Gamebot: A visualization-augmented chatbot for sports game," *Proceedings of the Conference on Human Factors in Computing Systems (CHI)*, 2020.

[16] G. Wallner, M. V. Wijland, R. Bernhaupt, and S. Kriglstein, "What playerswant: Information needs of players on post-game visualizations," *Proceedings of the Conference on Human Factors in Computing Systems (CHI)*, 2021.

[17] J. Wiske and T. Horky, "Digital and data-driven sports journalism," *Insights on Reporting Sports in the Digital Age*, pp. 31–48, 2021.

[18] Y. Fu and J. Stasko, "Supporting data-driven basketball journalism through interactive visualization," *Proceedings of the Conference on Human Factors in Computing Systems (CHI)*, p. 17, 2022.

[19] T. Lin, Z. Chen, J. Beyer, Y. Wu, H. Pfister, and Y. Yang, "The ball is in our court: Conducting visualization research with sports experts," *IEEE Computer Graphics and Applications*, vol. 43, pp. 84–90, 2023.

[20] T. Lin, Z. Chen, Y. Yang, D. Chiappalupi, J. Beyer, and H. Pfister, "The quest for : Embedded visualization for augmenting basketball game viewing experiences," *IEEE Transactions on Visualization and Computer Graphics*, vol. 29, pp. 962–971, 2023.

[21] L. Jin and D. C. Banks, "Tennisviewer: a browser for competition trees," *IEEE Computer Graphics and Applications*, vol. 17, pp. 63–65, 1997.

[22] T. Polk, J. Yang, Y. Hu, and Y. Zhao, "Tennivis: visualization for tennis match analysis," *IEEE Transactions on Visualization and Computer Graphics*, vol. 20, pp. 2339–2348, 2014.

[23] X. He and Y. Zhu, "Tennismatchviz: A tennis match visualization system," in *Proceedings of the International Conference on Visualization and Data Analysis (VDA)*, vol. 28, 2016, p. 1–7.

[24] S. Pokharel and Y. Zhu, "Analysis and visualization of sports performance anxiety in tennis matches," in *Proceedings of the 13th International Symposium on Visual Computing (ISVC), Lecture Notes in Computer Science (LNCS)*, vol. 11241. Springer, 2018, p. 407–419.

[25] ——, "Tactical rings: A visualization technique for analyzing tactical patterns in tennis," in *Proceedings of International Symposium of Visual Computing (ISVC), Lecture Notes in Computer Science (LNCS)*, vol. 11845. Springer, 2019, p. 481–491.

[26] S. Pokharel, Y. Zhu, and S. Puri, "Micro-level analysis and visualization of tennis shot patterns with fractal tables," in *2019 IEEE 43rd Annual Computer Software and Applications Conference (COMPSAC)*. IEEE, 2019, p. 97–102.

[27] J. Wu, Z. Guo, Z. Wang, Q. Xu, and Y. Wu, "Visual analytics of multivariate event sequence data in racquet sports," *Proceedings of IEEE Conference on Visual Analytics Science and Technology (VAST)*, pp. 36–47, 2020.

[28] S. Pokharel and Y. Zhu, "Data visualization and analysis of playing styles in tennis," in *Proceedings of the International Conference on Visualization and Data Analysis (VDA)*, vol. 33, 2021, pp. 319–1–319–8.

[29] J. Wu, D. Liu, Z. Guo, Q. Xu, and Y. Wu, "Tacticflow: Visual analytics of ever-changing tactics in racket sports," *IEEE Transactions on Visualization and Computer Graphics*, vol. 28, pp. 835–845, 2022.

[30] Y. Wu, J. Lan, X. Shu, C. Ji, K. Zhao, J. Wang, and H. Zhang, "iTTVis: interactive visualization of table tennis data," *IEEE Transactions on Visualization and Computer Graphics*, vol. 24, pp. 709–718, 2018.

[31] J. Wang, K. Zhao, D. Deng, A. Cao, X. Xie, Z. Zhou, H. Zhang, and Y. Wu, "Tac-simur: tactic-based simulative visual analytics of table tennis," *IEEE Transactions on Visualization and Computer Graphics*, vol. 26, pp. 407–417, 2019.

[32] J. Wang, J. Wu, A. Cao, Z. Zhou, H. Zhang, and Y. Wu, "Tac-miner: Visual tactic mining for multiple table tennis matches," *IEEE Transactions on Visualization and Computer Graphics*, vol. 27, pp. 2770–2782, 2021.

[33] J. Lan, J. Wang, X. Shu, Z. Zhou, H. Zhang, and Y. Wu, "Rallycomparator: visual comparison of the multivariate and spatial stroke sequence in table tennis rally," *Journal of Visualization*, vol. 25, pp. 143–158, 2021.

[34] J. Lan, Z. Zhou, J. Wang, H. Zhang, X. Xie, and Y. Wu, "Simuexplorer: Visual exploration of game simulation in table tennis," *IEEE Transactions on Visualization and Computer Graphics*, vol. 29, pp. 1719–1732, 2023.

[35] N. Gershon and W. Page, "What storytelling can do for information visualization," *Communications of the ACM*, vol. 44, pp. 31–37, 8 2001.

[36] E. Segel and J. Heer, "Narrative visualization: Telling stories with data," *IEEE Transactions on Visualization and Computer Graphics*, vol. 16, pp. 1139–1148, 2010.

[37] R. Kosara and J. MacKinlay, "Storytelling: The next step for visualization," *Computer*, vol. 46, pp. 44–50, 2013.

[38] Q. Zhi, S. Lin, T. Sukumar, and R. Metoyer, "Gameviews: Understanding and supporting data-driven sports storytelling," *Proceedings of the Conference on Human Factors in Computing Systems (CHI)*, 2019.

[39] "Tennis scores live," https://www.tennislive.net/, Last accessed on 2023-04-28.

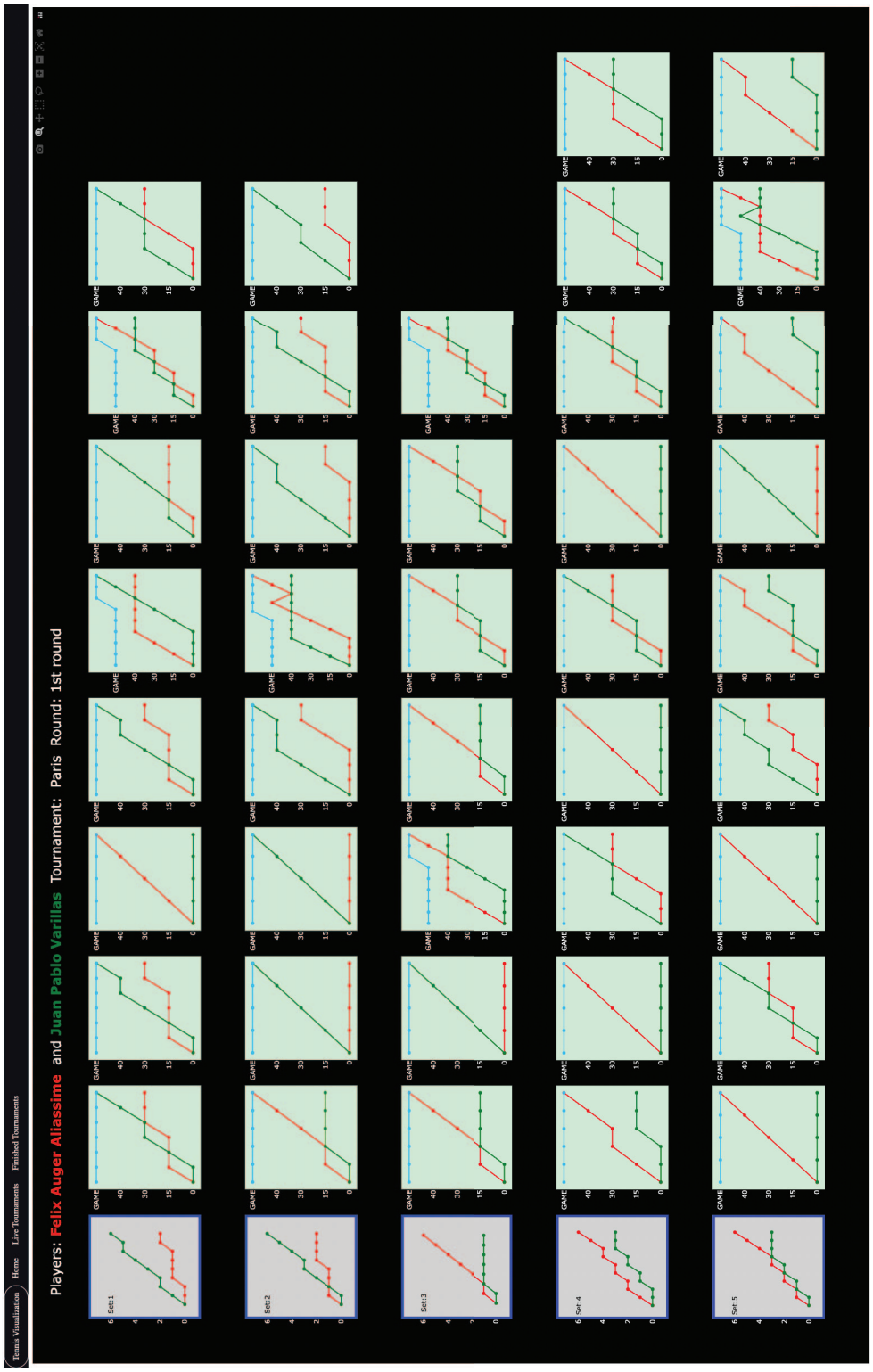


Fig. 5: Visualization of a five-set match between two professional players