HotShots: Visualizing Stroke-by-Stroke Tennis Data

Arvind Srinivasan* Abhinav Kannan† Niklas Elmqvist‡

College of Information Studies
University of Maryland, College Park

Figure 1: **The HotShots Tennis Visualization System.** We visualize stroke-by-stroke tennis data on a visual representation of the court. Filter allows for limiting the strokes to be shown: (a) in time, (b) in space, and (c) by stroke type (net, out, win, serve, etc).

Abstract

Post-match visualizations in tennis match data available to the common public are largely limited to video highlights and tabular reports (also called "score cards"). Such systems tend to ignore an important aspect of the game: ball location. We therefore felt a need for an interactive and accessible interface that prioritizes and simulates strokeplay, and provides end-users with customizable options to filter portions of interest. We propose HotShots, an interactive website with a tennis court representation that provides more profound insights into tennis player behavior. We conclude by presenting how this might shape future systems that would better serve tennis analysts and enthusiasts. A prototype of this tool is available at `https://hotshots-v2.vercel.app/`.

Index Terms: visualization, tennis, accessibility, sports data

1 Introduction

In the recent decade, detailed stroke-by-stroke data from major tennis events have been recorded using a combination of ultra high-speed cameras and high-speed lasers [1]. These sensors have been directly integrated into court surfaces, helping track every single ball and player movement. Such advancements in technology have greatly enabled smarter in/out line-calls—and therefore, fairer umpiring. However, this data is both difficult and expensive to obtain, and therefore largely limited to higher-ranked professional players.

On the other hand, there is a long history of enthusiastic tennis fans crowdsourcing stroke-by-stroke data from televised tennis matches—one website aggregating such data is Tennis Abstract[1]. Rather than real-time telemetry of player and ball location, as when using the state-of-the-art systems discussed above, these recordings describe the general location of each stroke in a match. While this crowdsourcing approach has made the stroke data accessible to the public, we still lack a tool to explore such stroke data and find insights from them easily.

We present HotShots, a web-based visualization system for democratizing access and analysis to such crowdsourced stroke-by-stroke tennis data. The key feature of HotShots is based on a fundamental need among tennis enthusiasts: navigating and filtering among the thousands of strokes in a single match. We achieve this by providing filtering functionality (a) by time (the temporal location during a match), (b) by space (the location where a ball is returned), and (c) by stroke type (whether the ball was a serve, hit the net, went out of bounds, or was a winner).

*email: arvindrb@umd.edu
†email: abhinavk@umd.edu
‡email: elm@umd.edu

[1] `http://www.tennisabstract.com/`

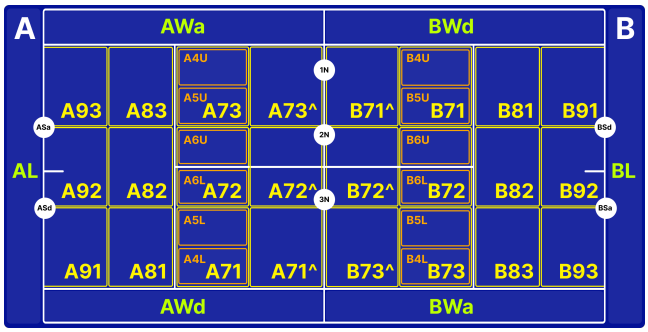

Figure 2: **Court zones.** Zones on a tennis court parsed from the data recorded by the Tennis Abstract website.

2 Related Work

We found that most insightful representations are largely based on scores and match statistics [3,5,6], while just a handful are based on strokeplay [2,4]. From our findings, rally data represented on the court are most easily interpretable since they closely simulate strokeplay. However, these are largely restricted to televised broadcasts; thus fueling our motivation to prototype a court-based visualization.

3 Visualizing Stroke-by-Stroke Tennis Data

HotShots is a visualization system for displaying spatiotemporal tennis stroke data. Here we describe the details of the system.

3.1 Data Source

We retrieve our data from `http://www.tennisabstract.com/`, a web portal of tennis match data obtained by crowdsourcing. Such data is recorded at a match level. The format of a match is such that every stroke is represented using a stroke code (e.g., "f" implies forehand, and "b" implies backhand"). Every stroke code is accompanied by a number indicating shot direction (e.g., "1" covers the deuce-side of the court, while "3" covers the ad-side) and depth (e.g., "7" is the area closer to the net, while "9" is towards the baseline). For example, a stroke "f39" hit by player A would imply a forehand from player A to player B's ad-side, landing in box B93 (Fig. 2).

3.2 Stroke Representation

We use a spatiotemporal visualization of stroke-by-stroke data on an overhead map of a tennis court. Each stroke is represented by a color-coded tapered line increasing in width from the origin to the destination zone. Each endpoint is marked using a white circle (which can be toggled on and off); in addition, special stroke types have an icon in that circle.

3.3 Filtering Mechanisms

We provide three main mechanisms for filtering stroke-by-stroke data in HotShots:

- **Time:** The user can select a region of the match to display using a range slider on the match timeline at the top of the screen (Fig. 1(a)). The y-axis represents the rally length for each point of the match marked on the x-axis.
- **Space:** The user can directly select which zones to display by clicking on the court, thus highlighting that zone (Fig. 1(b)). All strokes that do not originate or terminate in that zone will be filtered out. Clicking multiple zones will yield a conjunction, only displaying strokes that involve them all.
- **Stroke type:** Strokes can be toggled depending on their type: regular strokes, serves, aces, faults, strokes that end in the net, go out of bounds, or yield a win (Fig. 1(c)).

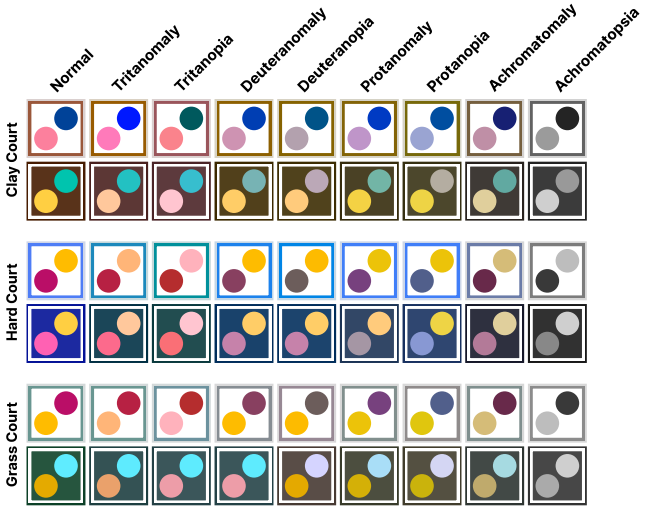

Figure 3: **Color vision deficiency appearance.** Color choices for accessible court representations.

3.4 Implementation Details

We have used React to build the web application along with JavaScript libraries from D3.js (`https://d3js.org/`). User interface elements were built using Material UI (`https://mui.com/`).

We designed HotShots to be accessible to people with color vision deficiency (CVD). Fig. 3 shows an overview of the accessible color choices for court representations under various forms of CVD.

4 Conclusion and Ongoing Work

We have presented HotShots, a web-based spatiotemporal visualization system for stroke-by-stroke tennis data. The system's main feature focuses on what tennis fans want: navigating and filtering by time, space and stroke type, in a way that is more accessible and democratized. Going forward, we plan to conduct user-based research to evaluate its accessibility and improve stroke-by-stroke insights with the filtering mechanisms offered by the interface.

Acknowledgments

The authors wish to thank Md Naimul Hoque at the University of Maryland, College Park for his advice and feedback.

References

[1] J. Chua. An overview of smart tennis courts 2020. Available: Link, 2020.

[2] C. M. Floyd, M. Hoffman, and E. Fokoue. Shot-by-shot stochastic modeling of individual tennis points. *Journal of Quantitative Analysis in Sports*, 16(1):57–71, Mar. 2020. doi: 10.1515/jqas-2018-0036

[3] X. He and Y. Zhu. TennisMatchViz: A tennis match visualization system. *Electronic Imaging*, 28(1):1–7, Feb. 2016. doi: 10.2352/ISSN.2470-1173.2016.1.VDA-504

[4] S. Kovalchik and M. Reid. A shot taxonomy in the era of tracking data in professional tennis. *Journal of Sports Sciences*, 36(18):2096–2104, Feb. 2018. doi: 10.1080/02640414.2018.1438094

[5] S. Pokharel and Y. Zhu. Analysis and visualization of sports performance anxiety in tennis matches. In *Proc. 13th International Symposium on Visual Computing, Lecture Notes in Computer Science*, vol. 11241, pp. 407–419. Springer, Cham, 2018. doi: 10.1007/978-3-030-03801-4_36

[6] T. Polk, J. Yang, Y. Hu, and Y. Zhao. TenniVis: Visualization for tennis match analysis. *IEEE Transactions on Visualization and Computer Graphics*, 20(12):2339–2348, Dec. 2014. doi: 10.1109/tvcg.2014.2346445