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Data Visualization and Analysis of Playing Styles in Tennis

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Abstract

Sports data analysis and visualization are useful for gaining insights into the games. In this paper, we present a new visual analytics technique called Tennis Fingerprinting to analyze tennis players' tactical patterns and styles of play. Tennis is a complicated game, with a variety of styles, tactics, and strategies. Tennis experts and fans are often interested in discussing and analyzing tennis players' different styles. In tennis, style is a complicated and often abstract concept that cannot be easily described or analyzed. The proposed visualization method is an attempt to provide a concrete and visual representation of a tennis player's style. We demonstrate the usefulness of our method by analyzing matches played by Roger Federer and Rafael Nadal at Wimbledon, Roland Garros, and Australian Open. Although we focus on tennis data analysis and visualization in this paper, this idea can be extended to the analysis of other competitive sports, including E-sports.

Introduction

Sports data visualization and visual analytics is an effective medium to communicate the happenings, details, and otherwise obscure patterns in a match. Thus, data visualization and analytics are being extensively used not just in the analysis of sports but also in the form of news dissemination to augment the understanding of fans. For example, in 2020, the Australian Open Tennis Championship partnered with Infosys to provide viewers with a set of data visualizations (e.g., MatchBeats, Stats+, CourtVision, and Rally Analysis) for realtime match analytics.

Traditional tennis analytics generally focuses on high-level statistics, such as serve percentages, number of unforced errors, etc. As more detailed, shot-by-shot data sets become available, more micro-level data analysis techniques have been developed to reveal deeper insight into the dynamics of tennis matches. Commonly used low-level data visualizations include heatmap, ball trajectory chart, and ball contact locations. However, these visualization techniques do not sufficiently capture a tennis player's distinctive style of play.

Tennis experts and fans like to discuss tennis players' different styles. It is part of the joy of tennis. However, such analyses are often abstract and oversimplified. Players are labelled as "aggressive", "all-court player", "defensive", or "grinder". Such labels are often too simplistic and do not accurately capture the details and the dynamic nature of a player's style.

In this paper, we present a new method to visualize a player's distinctive pattern of play. The goal is to visualize the characteristics of a tennis player's game, such as serve patterns and return patterns. Here we use the term "fingerprint" to refer to the characteristic of a player's game. Therefore, the proposed visualizations are used to show the "fingerprint" of a player's pattern of play.

The analysis presented in this paper is based on micro-level performance data from professional tennis matches. Although we focus on tennis in this paper, this idea can be extended to the analysis of other sports (including Esports), if micro-level performance data is available.

Related Works

Traditional tennis analytics focuses on analyzing high-level statistics, such as serve percentages, serve winning percentages, etc. These statistics mostly deal with the outcome of points, games, and matches, not how the points are played. More recently, Wei, et al. used vision-based tennis ball tracking data to predict tennis players' serves [1] and shot directions [2].

Various visualization methods have also been proposed for tennis analytics. Jin [3] proposed a technique to visualize the overall structure of the match as well as the fine details using a 2D display of translucent layers derived from Tree-Maps. He and Zhu [4] proposed a data visualization that shows the progression and tactical statistics of a tennis match. Polk, et al. developed a tennis match visualization system that shows the score, point outcomes, point lengths, service information, and match videos [6]. Burch, et al. [7] introduced techniques to visually encode the dynamics of a tennis match with the use of hierarchical and layered icicle representations.

The work presented in this paper is different from previous works in that we focus on visualizing a player's style, not the outcome of the points, games, or matches. This work was inspired in part by the previous work on literature analytics through visual fingerprinting [25]. We are interested in applying a similar technique to tennis analytics.

Data

Our analysis is based on the crowd-sourced Tennis Match Charting Project [34] that provides shot-by-shot data of more than 5000 professional tennis matches, including types of shot, directions of shots, depth of returns, types of errors, etc. The shot-by-shot data was created by human charters who watched the match videos and manually entered the data.

Method

Tennis Fingerprinting:

Tennis fingerprinting is an attempt to visualize a tennis player's distinctive playing style. For example, it displays a player's pattern of serves and returns of an entire match on a point-by-point basis. In this visualization, each block represents a point. Each point is color-coded for a particular variable to be

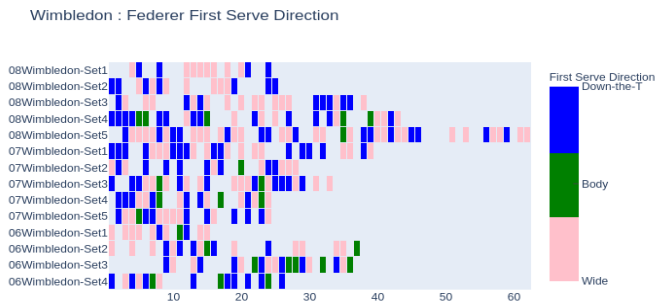

Figure 1. *Federer First Serve at Wimbledon*

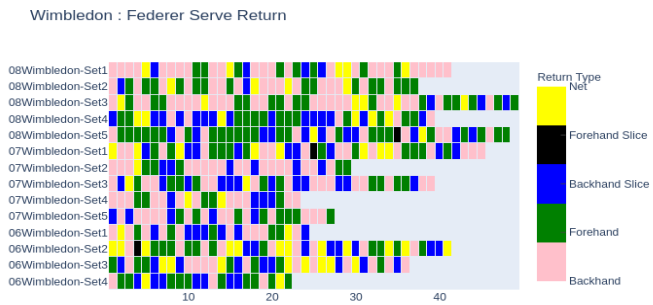

Figure 2. *Federer Serve Return at Wimbledon*

analyzed (such as serve, return, and rally). Each horizontal line corresponds to a set. In this paper, we focus on two tactical patterns: serve pattern and return pattern. More tactical patterns can be explored using this type of visualization but due to space limit we will discuss them in the future.

Serve Directions:

Serve is often considered the most important shot in professional tennis. In a tennis match, a player serves alternatively from two sides of the court: deuce side and ad side. On each side, the player has two chances to serve: first serve and second serve. If both serves are missed, it is called a double fault. For each serve, a player can decide to serve in three directions: wide, body, and down-the-T. The serve direction is also called serve placement.

In professional matches, serve speed and placement are both very important. Serve placement is often part of a tactical plan in which a player tries to win a point by a combination of shots, starting with the serve. Because of this, choosing the direction for each serve is often a complicated decision that may involve the following variables: serve side (deuce or ad), first or second serve, server's strength and weaknesses, the opponent's strengths and weaknesses, current scores, court surface condition, and wind condition. In the mean time, a player also tries to make the serve directions unpredictable to the returner.

Serve Return:

Returning serve is also a very important shot in professional tennis. Good returns can create many opportunities to win points and break the opponent's service games. A player's return patterns also reveals his/her tactical decision making. For example, a player can choose to return with backhand or run around to return with a forehand, which is aggressive but risky. However, the types of return shots are often dictated by the serve directions. Therefore, the return pattern is also partly a reflection of the server's serve patterns.

Visualization Design:

Figures 1 and 2 shows two examples of the proposed data visualization. Figure 1 visualizes the serve patterns. Figure 2 visualizes the service return patterns. The vertical axis shows different sets in selected tennis matches. The horizontal axis is the timeline. Therefore, each row represents the points of a set in a tennis match. Each color-coded block represents a serve or return. For serve patterns, pink represents a wide serve; green represents a serve to the body; blue represents a serve down-the-T. The color coding for the return of serves is as follows. Pink represents a backhand return; green represents a forehand return; blue represents a backhand slice; black represents a forehand slice; yellow represents a return to the net.

Visual Analytics

The proposed data visualizations can help users visually analyze a player's playing style. For example, it can be used to answer the following questions.

1. Does a player have a preferred service direction? Is a player's service pattern consistent or change from match to match? Which serve pattern works well against a particular opponent?
2. Does a player have a preferred service-return pattern? What kind of return pattern works well against certain opponent?
3. Can we visually see the difference between the styles of different players?
4. Can we visually compare a player's serve or return patterns between matches to see if a player adjusted his/her serve, return style for different opponents?

Case Studies

In this section, we use several case studies to demonstrate the application of our proposed visualizations. We use the data [34] from three matches played by Rafael Nadal and Roger Federer at Wimbledon (grass court) from 2006 to 2008, the five matches between them in the French Open at the Roland Garros (clay court) from 2005 to 2011 and the two matches in the Australian Open (hard court) in 2009 and 2012.

First Serve Pattern Analysis

In this section, we analyze the first serve patterns for both players at Wimbledon, Roland Garros (French Open), and the Australian Open, respectively.

Figures 1 and 3 shows Federer and Nadal's first serve patterns at Wimbledon (grass court). From the visualizations, we can clearly see that in Figure 1 Federer tended to serve more wide (pink) than down-the-T (blue). Looking at the bars horizontally, we can see that Federer sometimes served wide in consecutive serves. He made only a small number of serves to the body (green). But interestingly, he made a cluster of the body serves

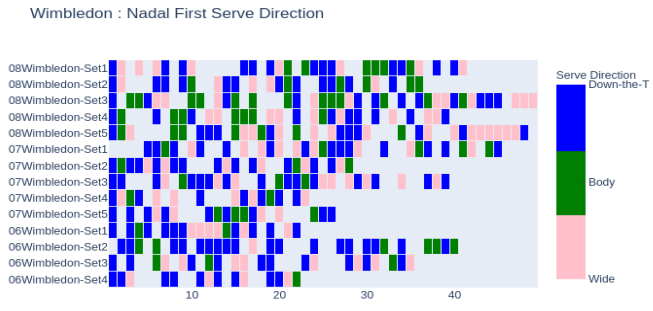

Figure 3. *Nadal First Serve at Wimbledon*

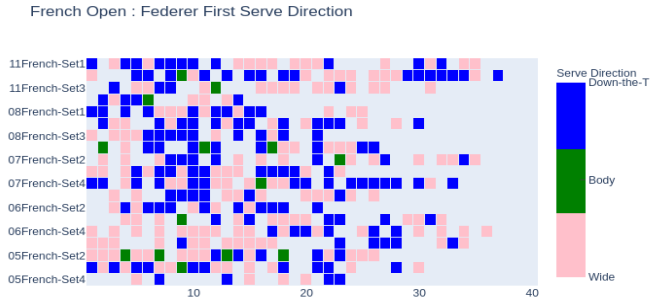

Figure 4. *Federer First Serve at Roland Garros*

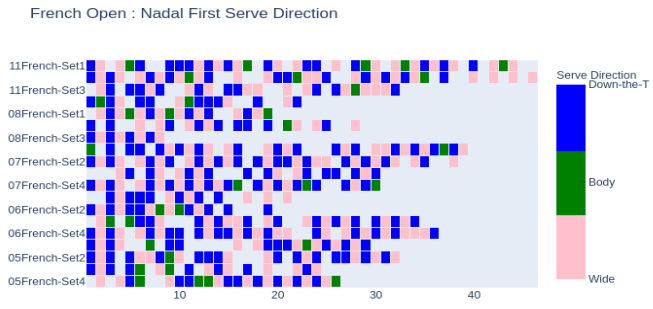

Figure 5. *Nadal First Serve at Roland Garros*

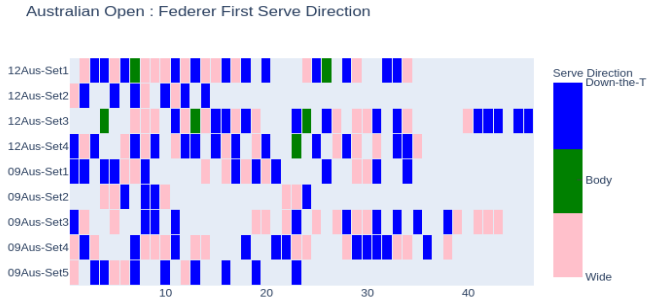

Figure 6. *Federer First Serve at Australian Open*

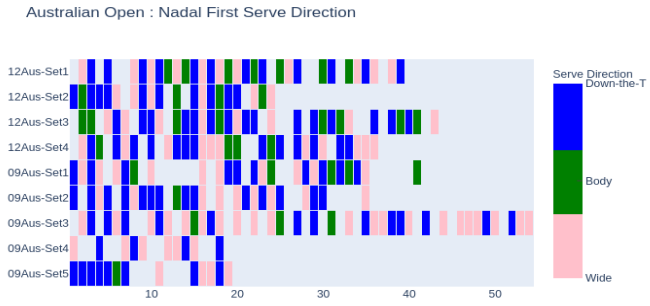

Figure 7. *Nadal First Serve at Australian Open*

in the third and fourth set of the 2006 match.

In contrast, Nadal's first serves at Wimbledon was more balanced, with similar numbers of wide, body, and down-the-T serves. Nadal made more body serves than Federer. Looking vertically at Nadal's figure, we can see that he tended to start each set serving down-the-T, as indicated by the vertical blue bars on the left side of figure 3.

Figures 4 and 5 show Federer and Nadal's first serve patterns at Roland Garros (clay court). The contrast between the two players is quite obvious. In figure 4 Federer preferred to serve wide or down-the-T, and made only a small number of the body serves. It seems that Federer liked to serve in clusters: consecutive wide or down-the-T serves, as visualized by the long horizontal pink and blue bars. In contrast, Nadal's serves are a mixed picture, seemly more random, with no obvious clusters. Again, we see Nadal had a tendency to start each set serving down-the-T, as indicated by the vertical blue bars on the left side of figure 5.

Figures 6 and 7 show Federer and Nadal's first serve patterns at the Australian Open (hard court). Again, we can see that Federer did not like to serve to the body. In the 2009 match (bottom half of figure 6), there seems to be no body-serve. Again, Nadal's serves are more mixed. We still see strong examples of Nadal's tendency to start a set serving down-the-T. In figure 7, we can see two clusters of down-the-T serves (blue bars) at the beginning of two sets.

By analyzing the visualization of serve patterns for the three major tournaments, we can see some consistent patterns for each player. Federer took more risks in his first serves, serving wide

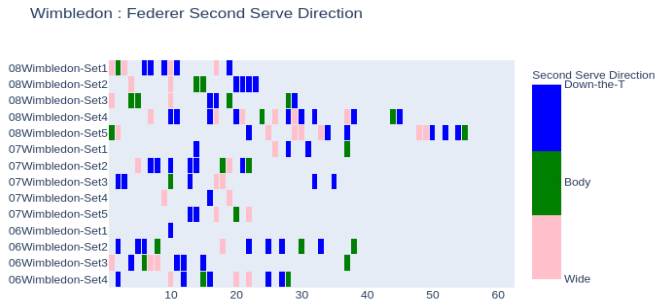

Figure 8. *Federer Second Serve at Wimbledon*

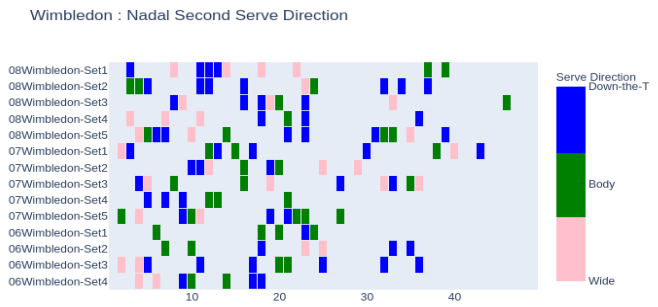

Figure 9. *Nadal Second Serve at Wimbledon*

and down-the-T and only a small number to the body. He tended to serve wide in consecutive serves, showing high confidence in this serve placement. Nadal's serves seem more mixed and random, but he had the tendency of serving down-the-T at the beginning of a set, perhaps a sign of confidence in this serve placement. From the visualization, we see no obvious change in each players first serve patterns on different court surfaces, indicating a largely consistent serving style.

Second Serve Pattern Analysis

Players are generally less aggressive in their second serves. As a result, second serves are generally slower than the first serves, and the placements of second serves also have more margin for errors. Therefore, there is generally more second serves to the body than the first serves. Figures 8 and 9 show the second serve patterns for both players at Wimbledon (grass court). The difference between their second serve patterns is not as distinctive as their first serve patterns, although Nadal still served more to the body (green) than Federer. Both players served more down-the-T (blue) than wide (pink).

Figures 10 and 11 shows the second serve patterns for both players at Roland Garros (clay court). Both players served more to the body (green), particularly Federer. Compared with Wimbledon, Federer served more wide (pink) than down-the-T (blue). Again, Nadal's second serves are more evenly mixed. We also notice that Nadal chose to serve down-the-T (blue) at the start of multiple sets.

Figures 12 and 13 shows the second serve patterns for both

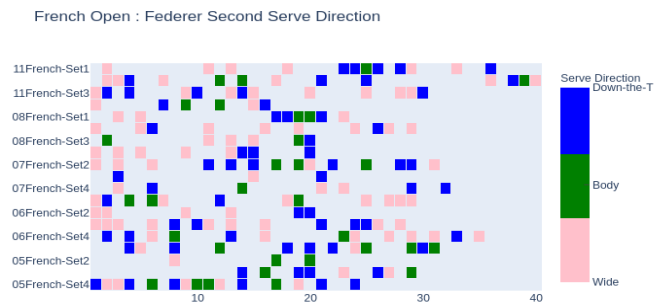

Figure 10. *Federer Second Serve at Roland Garros*

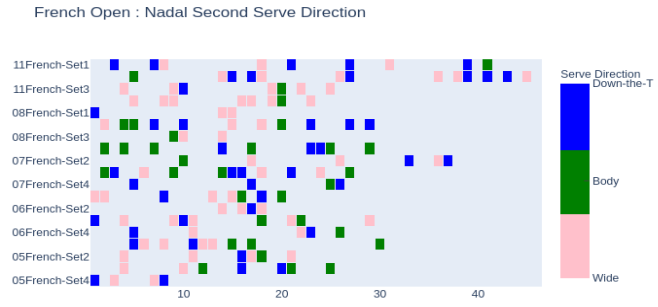

Figure 11. *Nadal Second Serve at Roland Garros*

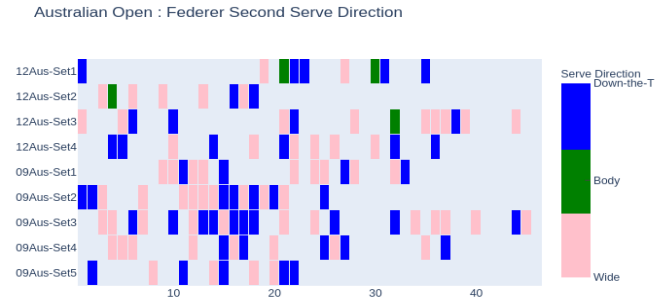

Figure 12. *Federer Second Serve at Australian Open*

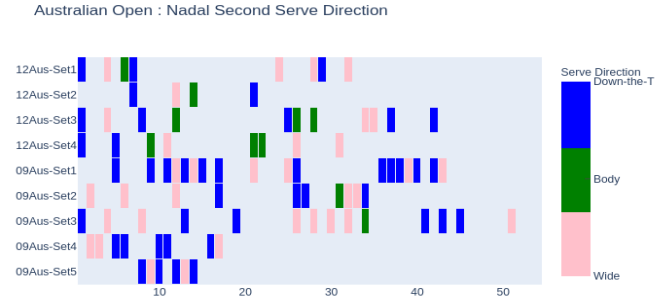

Figure 13. *Nadal Second Serve at Australian Open*

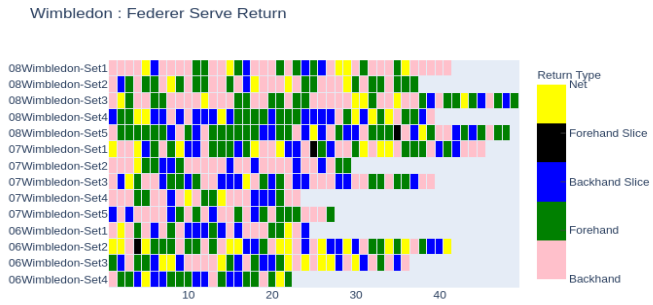

Figure 14. *Federer Serve Return at Wimbledon*

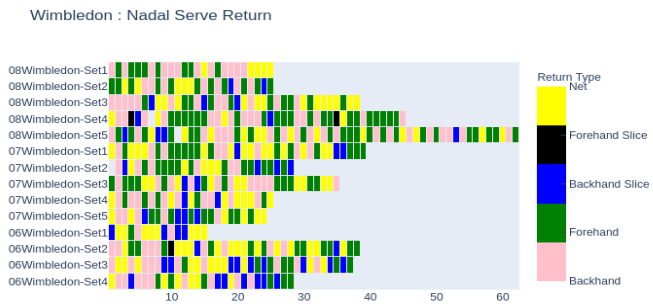

Figure 15. *Nadal Serve Return at Wimbledon*

players at the Australian Open (hard court). Again, we can see Federer made only a few body serves, and Nadal started four sets with serving down-the-T (see the blue bars on the left of Figure 13.

From the visual analysis, we see that Federer was still taking more risks in his second serves, opting to serve more to wide and down-the-T. However, on his less favorite clay courts, he seemed to be more cautious and served more to the body. Nadal's second serves are more or less evenly mixed, like his first serves. However, we also get a glimpse of his tendency to serve down-the-T at the beginning of many sets. Even in second serves, the visual patterns seem to suggest that Federer slightly favored wide serves while Nadal slightly favored down-the-T serves.

Return Pattern Analysis

In this section we analyze the service returns for both players on grass, clay, and hard courts.

Figures 14 and 15 show the service return patterns for both players at Wimbledon (grass court). From the visualization (Fig. 14), we can see that Federer made many backhand returns (pink) in the first three sets of their famous 2008 match. However, in the fourth and fifth sets, Federer made notably fewer backhand returns but more forehand returns (green) and backhand slice returns (blue). Again, in the final set of their 2006 match, we also see very few backhand returns (pink). Does this indicate a change in Federer's return strategy or Nadal's serves strategy? The visual analysis raises an interesting question.

On the other hand, in Fig. 15 Nadal made fewer backhand re-

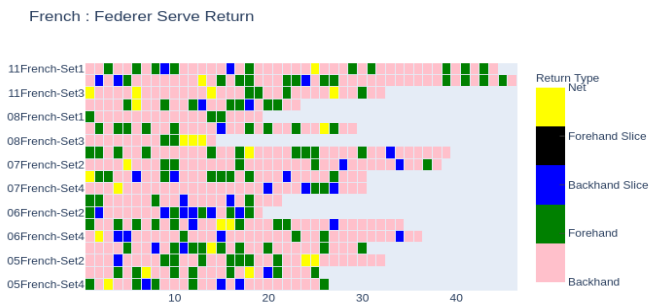

Figure 16. *Federer Serve Return at Roland Garros*

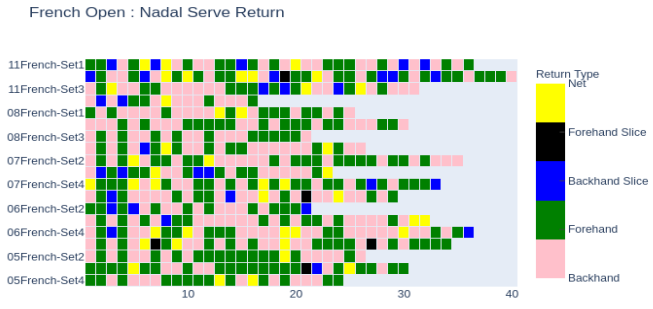

Figure 17. *Nadal Serve Return at Roland Garros*

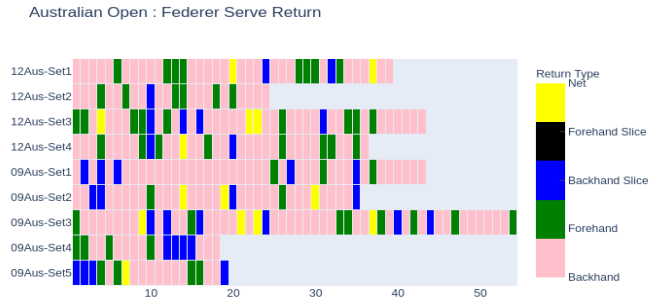

Figure 18. *Federer Serve Return at Australian Open*

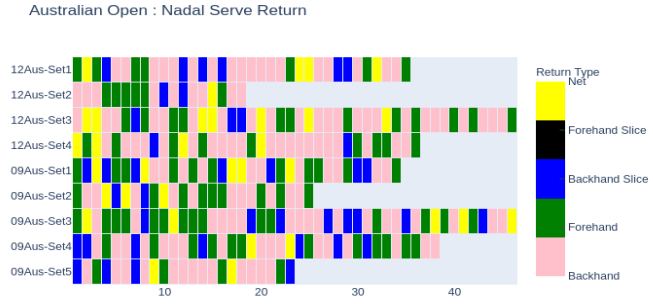

Figure 19. *Nadal Serve Return at Australian Open*

turns (pink) and very few backhand slices (blue), perhaps because he has a two-handed backhand. However, Nadal made more errors than Federer returning to the net (yellow), an indicator of the effectiveness of Federer's serves on grass courts.

Figures 16 and 17 show the service return patterns for both players at Roland Garros (clay court). From the visualization (Figure 17), we can see that Federer made far more backhand returns (pink) than other types of returns. This clearly shows Nadal's strategy of relentlessly serving to Federer's back on clay court. In the meantime, Nadal made many returns with his forehand (green). By comparing Fig. 14 and 16, we can see that Federer was forced to play a very different type of return game on clay. This is one of the reasons why he never performed well against Nadal on clay courts.

Figures 18 and 19 show the service return patterns for both players at the Australian Open (hard court). In Fig. 18, we can see that Federer was forced to make a large number of backhand returns (pink) like he did at Roland Garros. Comparing Figure 14, 16, and 18, we clearly see Nadal's strategy against Federer was serving to Federer's weaker backhand. But for some reason, Nadal was unable to do this to Federer on the grass court, or perhaps Federer was able to handle it effectively on the grass. It is an interesting question for further exploration. Comparing Fig. 15, 17, and 19, we do not see significant differences in Nadal's return patterns on different surfaces.

Conclusions

In this paper, we described a visualization technique to analyze tennis players' playing style. Tennis experts and fans are often interested in discussing and analyzing tennis players' different styles. Watching the clash of different styles, such as Federer and Nadal, is one of the main reasons many people enjoy tennis. However, style is also a complicated and often abstract concept that cannot be easily described or analyzed. The proposed visualization method is an attempt to provide a concrete and visual representation of a tennis player's style. This visualization technique, combined with expert knowledge, can lead to the discovery of deeper insight into this sport.

We demonstrated the usefulness of our methods with case studies of Federer and Nadal's matches at Wimbledon, Roland Garros, and Australian Open. Using our visualizations, we are able to discover some interesting patterns in both Federer and Nadal's service and return games. The contrast between the two players is clearly visible in our visualizations. In the current work, we only focused on serves and returns, the starting point of each point. In the future, we plan to expand our work to visualize tennis players' different styles of play during rallies.

Our idea can be extended other competitive sports to analyze player behavior and styles as long as micro-level performance data is available. This can be particularly useful for video games and Esports, where detailed performance data can be collected automatically in real-time.

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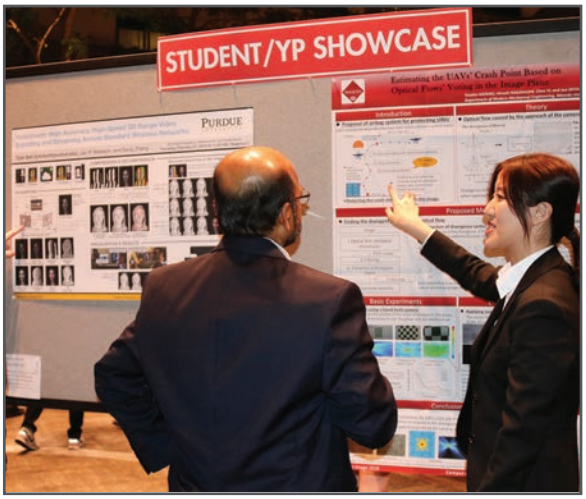

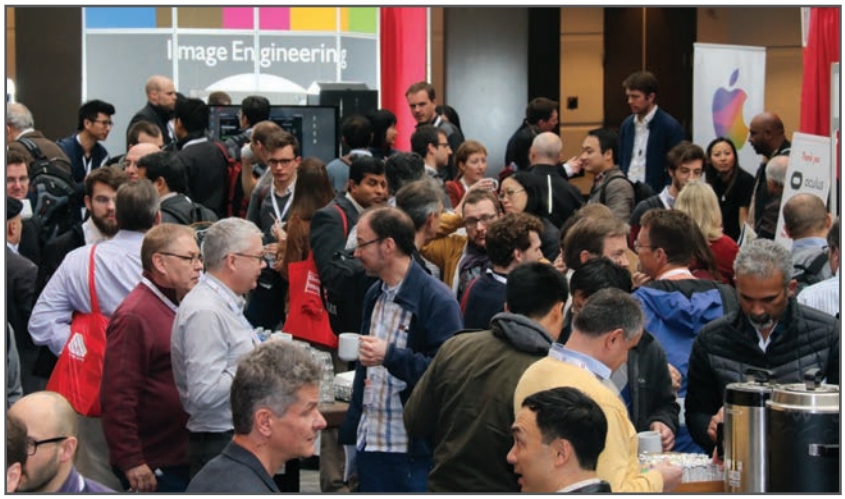

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