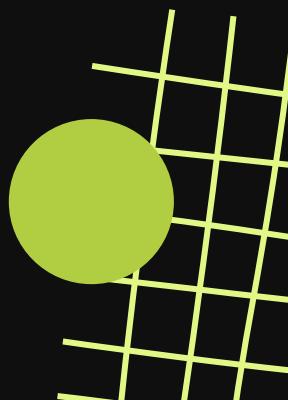


Tennis Server Quality Metric

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Motivation

- Existing research focuses extensively on match-level prediction (mostly ELO models)
- Basic serving statistics exist, but they tell an incomplete story of server dominance
- Room in the literature for an evaluation of servers in men's and women's tennis



Research Objectives



Group players by serve style: Clustering by serve speed, aces, location entropy, and modal serve location



Model serve outcomes: Using server statistics and clusters to predict point outcomes



Construct server quality metrics: Creating numerical scores to evaluate servers.

Clustering

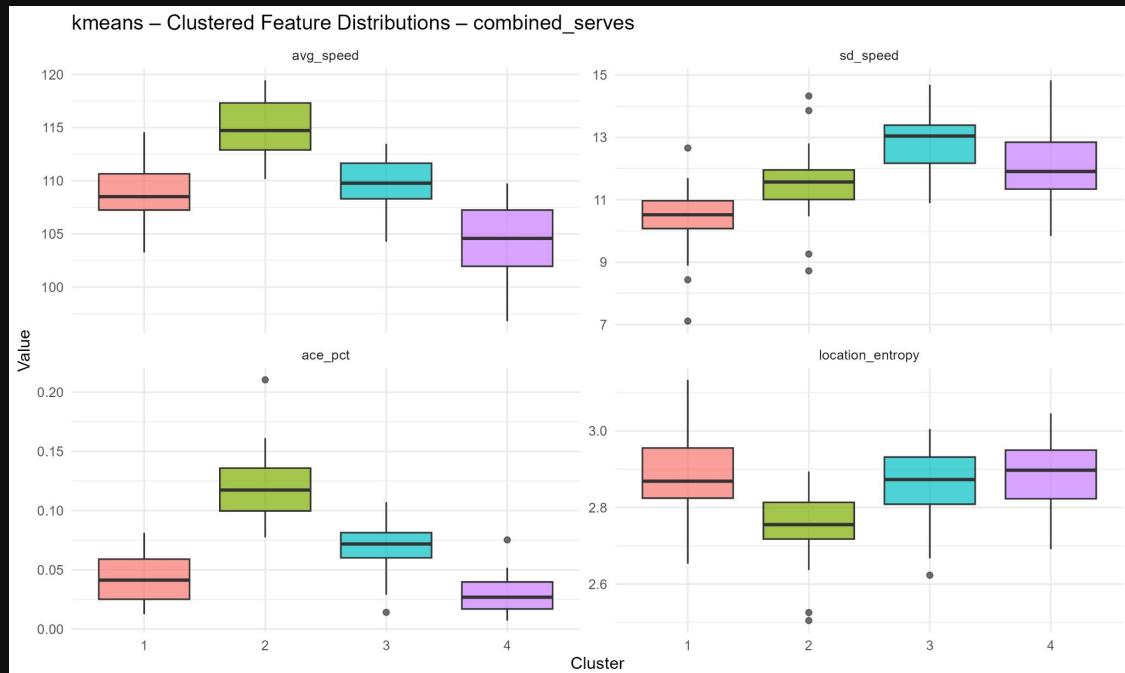


Modeling



Server Metrics

K-Means Clustering: Speed, Aces, Entropy



cluster	avg_speed	sd_speed
1	108.960916920795	10.4145155732768
2	114.815266722397	11.5776122609671
3	109.746322772352	12.9167511071142
4	104.32923706341	12.0743616614806

cluster	ace_pct	location_entropy
1	0.0433578436481444	2.872178922517
2	0.119837475337068	2.75073665561808
3	0.0706959470167434	2.86197448159623
4	0.0295168777819073	2.8866707644689

Data: Wimbledon Males, 2021-24, from [Jeff Sackmann's point-by-point grand slam data](#)

Server Quality Metrics

Residuals from Prediction Models

- General form of models: $(Win_pct \text{ or } serve_efficiency) \sim (avg_speed + sd_speed + location_entropy + factor(modal_location) + factor(cluster) + interactions \text{ of cluster with all other variables})$
- 3 models to predict win_pct or serve_efficiency: linear regression, random forest, and XGBoost
- Server metric = **scaled(prediction) + scaled(residual)**

Separate metrics using different data (Wimbledon/U.S. Open, males/females)
All metrics scaled to be between [-1, 1]

Server Quality Metrics

Weighted Average of Server Statistics

- Formula: $\sum [(Importance\ Score) * (player\ statistic)]$
- Player statistics: speed (average and sd), entropy, modal serve location (one-hot encoded)
- Importance scores from random forest model that predicts outcome variable (serve efficiency or win percentage)

Separate metrics using different data (Wimbledon/U.S. Open, males/females)
All metrics scaled to be between [-1, 1]

Server Quality Metrics

Weighted Elo

- Baseline metric: server's weighted Elo (wElo)
- Minimum wElo = 1500 in our datasets

Separate metrics using different data (Wimbledon/U.S. Open, males/females)
All metrics scaled to be between [-1, 1]

Outcomes for Prediction Models

Serve Efficiency

- Formula: $(\# \text{ points won as server where rally count} \leq 3) / (\text{total } \# \text{ points played as server})$
- How often a serve leads **rapidly** to a point win
- Might undervalue players with good serves who didn't win points quickly

(Point) Win Percentage

- Formula: $(\# \text{ points won as server}) / (\text{total } \# \text{ points played as server})$
- How often a serve leads to a point win, regardless of rally count
- More confounded by other factors (e.g., opponent skill; other hits during rally)

Out-of-sample Predictive Performance

Serve Efficiency (Wimbledon males)

1	cor	p_value	rmse	avg_metric	n	Model
2	0.502909180219369	9.11273224652082e-05	0.98798057154534	-9.2886557031849e-18	55	performance_lm
3	0.524026062162999	4.02518734147486e-05	0.966767672442521	5.20417042793042e-18	55	performance_rf
4	0.521279498615177	4.49032935644374e-05	0.969552981810417	1.0857791938273e-17	55	performance_xgb
5	0.514238774755903	5.91794182818541e-05	0.976656749290078	1.18631430436687e-17	55	weighted_avg
6	0.0214043186327044	0.875575490603796	0.990804165032057	-1.85565751597868e-15	56	avg_welo

Metrics based on 2021-24 data; tested on serve efficiency from 2018-19 data

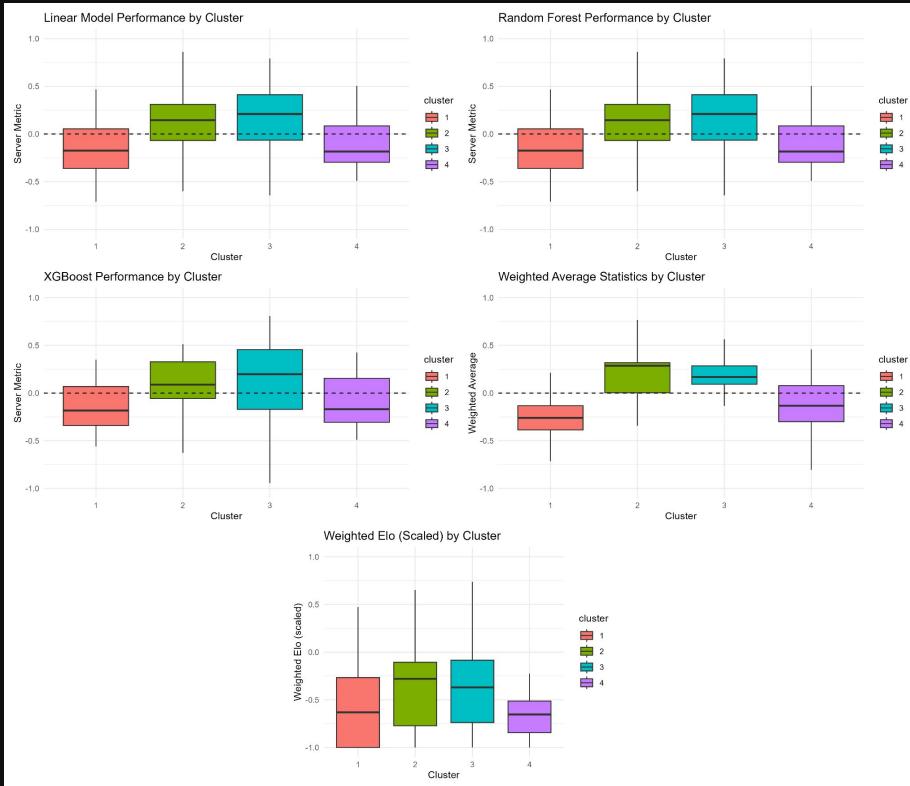
Out-of-sample Predictive Performance

Win Percentage (Wimbledon males)

1	cor	p_value	rmse	avg_metric	n	Model
2	0.309249505097055	0.0215953931066117	1.16463848038404	2.11517987468536e-17	55	performance_lm
3	0.298792693380145	0.0266984441446279	1.17342071130787	1.83895473028621e-17	55	performance_rf
4	0.311730967811898	0.0205136945428977	1.16254466562337	5.50183320619462e-18	55	performance_xgb
5	0.13516046428811	0.325175695971142	1.30316167877752	-1.93185114370144e-17	55	weighted_avg
6	0.284334647347935	0.0336846431777086	0.950126490239438	-1.85565751597868e-15	56	avg_welo

Metrics based on 2021-24 data; tested on win percentage from 2018-19 data

Distn of Server Quality Per Cluster



Server metrics based on
win_pct prediction models for
Wimbledon males data





Alexander Zverev



Serve Details

Average Serve Speed

119.448 mph

SD Serve Speed

11.783 mph



Metrics (based on serve efficiency; scaled from [-1, 1])

RF performance metric

0.887

Ace Percentage

0.116

Location Entropy

2.833

Weighted Stats

0.767

Modal Serve Location

WC - DNCTL

(center; not close to line)

Cluster

2

wElo (scaled)

-0.006

- Placed in “Powerhouse” server cluster
- Known for high speed, powerful serve

Future Work

- Adding serve spin and placement data to the metrics (if there is data)
- Ace percentage as an outcome variable
- Generate actionable insights for players (e.g., personalized training plan for certain serve styles and opponents)
- Server metric that updates live throughout a match