Markov Chains and Badminton

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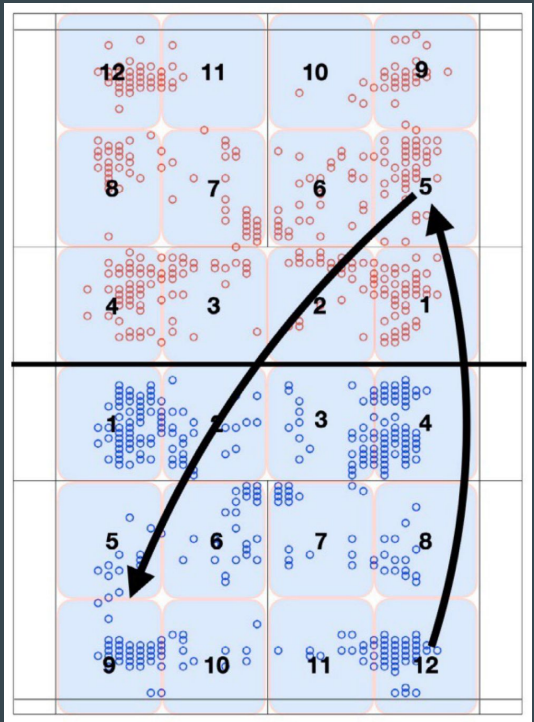
Introduction to the question - What is being researched?

- In recent decades, research has increased surrounding sports performance
  - Notational analysis using observational data
- Overarching Question: How can one predict the probability that a player wins a rally, set, or match in badminton?
  - Two main perspectives:
    - 1) Markov Chain model → to find the stroke with the highest probability of winning a rally
    - 2) Relationship between a sequence and gaining or losing “initiative”

An example



- A sequence or pattern that might appear in a match
  - 12→5→ 9
- Circles represent “striking locations”
- Court is divided into 12 sections or zones of equal size

Some basic information and definitions

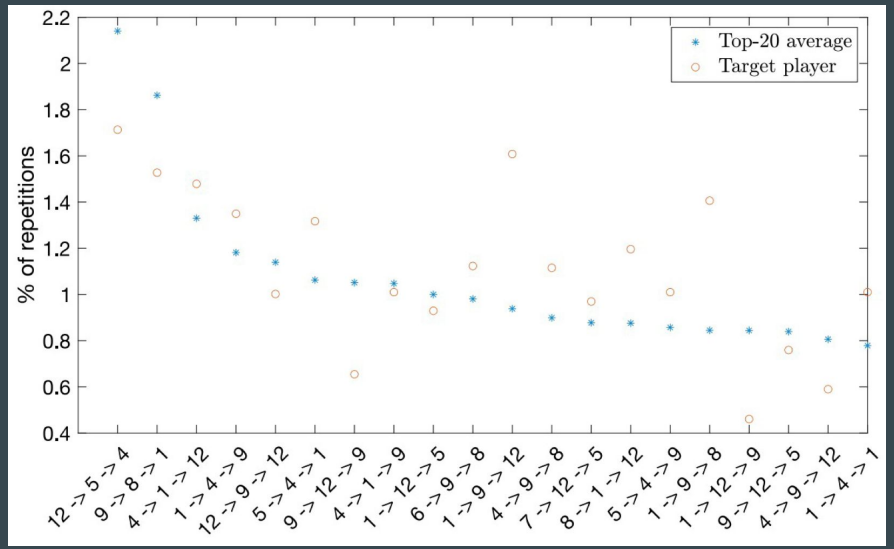
- A pattern
  - A sequence of 3 strokes
  - Notation example: **(1 → 2 → 3)**
- Initiative
  - Categorized by whether a player is in attack, construction, or defence
  - Assessed after each pattern
  - Calculate initiative gained for each pattern **(ΔI)**
  - Example formula: $\Delta I = (I_1)_{n+1} - (I_1)_n$
- Expected Pattern Value (EPV)
  - $\lim_{t\to\infty} M^t$ = The probability that a pattern S reaches each absorbing state = win or lose
  - $M^t[S+1, j]$ = row **S+1** in the transition matrix = P(win rally once pattern **j** appears)

Pattern Transition Model - Absorbing Markov Chains

- Finite Markov Chain
  - Transition from one **pattern** to another
- Discrete states: each pattern (x_n) of strokes
  - $S = (1 \rightarrow 1 \rightarrow 1, 1 \rightarrow 1 \rightarrow 2, \dots, 12 \rightarrow 12 \rightarrow 12)$
- Conditioned probabilities: $P\,(x_n \mid x_{n-1})$
- Absorbing states: win/lose
  - Length of Markov Chain = **S+2** (S+1 = win, S+2 = lose)
- Transition matrix tells us the probability of winning in terms of each pattern

Preferred Patterns

- Compares the average of top-20 players and a target player → shows preferred patterns

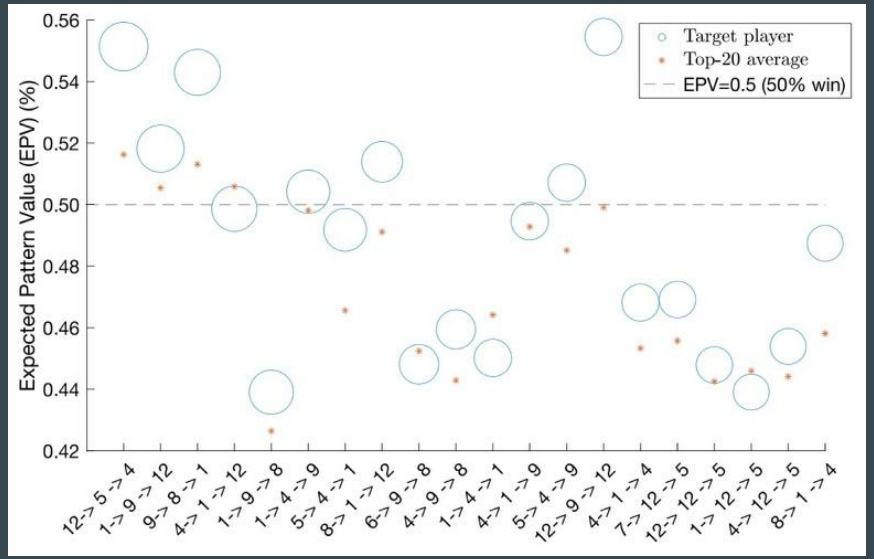


Some conclusions:

- Some patterns are more preferred by top-20 players than the target player and vice versa
- 1→9→12 has highest inconsistency which suggests a preference of the target player

Expected Pattern Value and Frequency of Appearance

- Shows the EPV of specific patterns and how frequently each pattern is used by target players

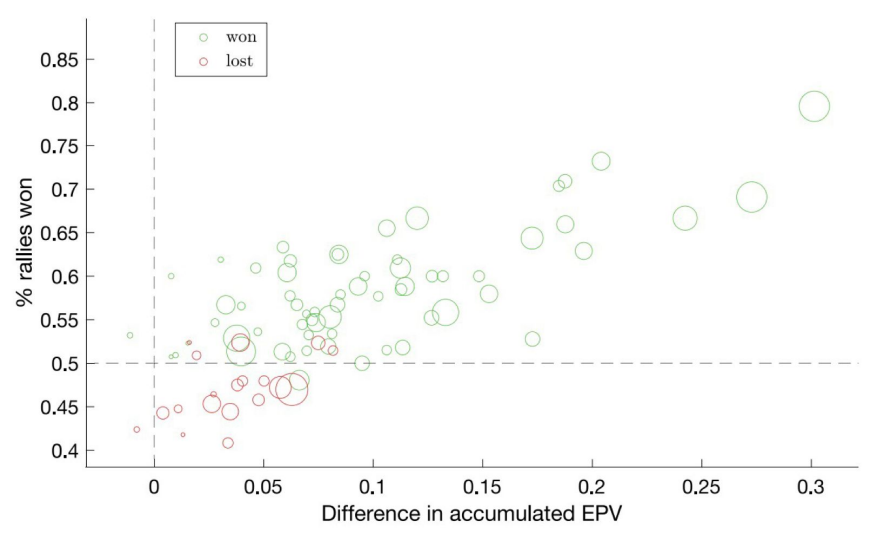


Some conclusions:

- Shows which patterns are more successful for a target player vs. a top-20 player
- E.g. target player successfully performs 12→9→12, but struggles with 1→4→1
- Significant when determining a player's strengths and weaknesses

Expected Pattern Value and Winning Outcomes

- Shows the relationship between EPV and percentage of rallies won at different matches (focuses on one top-five player)

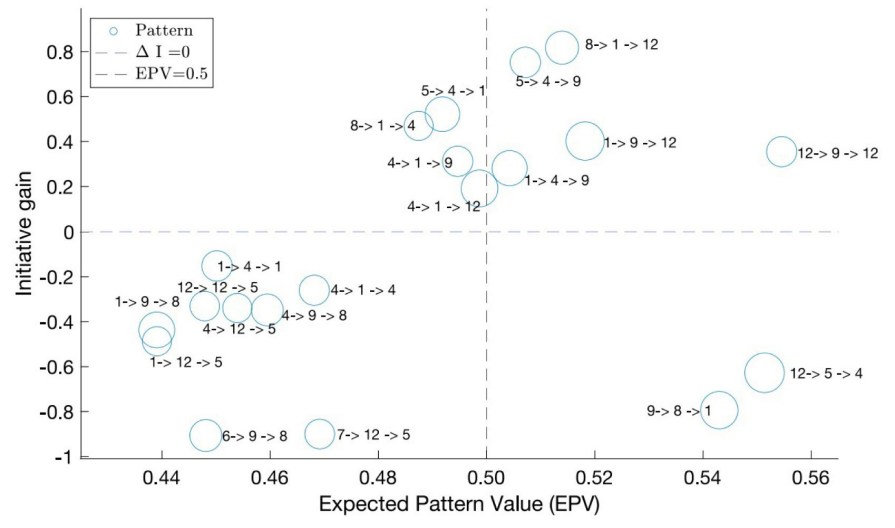


Conclusions:

- Matches won → related to higher probability of winning rally and higher EPV than opponent
- Matches lost → related to lower probability of winning rally and lower accumulated EPV
- For this player, having average higher EPV than opponent doesn't guarantee victory

Expected Pattern Value and Initiative Gain

- Shows EPV of different patterns and their resulting initiative gain or loss
  - 20 most repeated patterns of one top-5 player



Some trends:

- Decrease in initiative gain related to EPV < 0.5
- Increase in initiative gain related to EPV > 0.5

- Some patterns don't follow these trends

Conclusion, Insights and Limitations

Summary:

- Analyzed the performance of different striking patterns
- Each player has their own preference for striking patterns, which can help opponents strategize
- The Expected Pattern Value (EPV) is related to the probability of winning a match or rally based on specific patterns, which can help opponents anticipate their competitor's strengths and weaknesses

Limitations

- Relies on accuracy of datasets
- Markov Chains only take into account the striking locations

Thank you