



Carnegie Mellon University Statistics & Data Science

Background

- In 2024, NCAA developed a new ranking system in Division III called NCAA Power Index (NPI).
- NPI is calculated based on the result of matches and the strength of the opponent played.
- NPI will fully determine which university could make it to the playoff rounds of the NCAA DIII tournament via at-large bids.
- This gives us the incentive to optimize the schedule so that it could yield the highest expected NPI for Carnegie Mellon.



Data

- We use data from the ncaavolleyballr dataset from CRAN which contains every NCAA DIII Women Volleyball games in the past few years.
- We use match results to provide an estimation of the power balance between teams

1	date 🍦	team 🌣	opponent	result 🌻	attendance	contest 🍦	WL [‡]	home_score	away_sco
1	08/30/2024	Calvin	Carnegie Mellon	W 3-1	50	5667438	W	3	
2	08/30/2024	Denison	Carnegie Mellon	L 0-3	50	5667293	L	0	
3	08/31/2024	Albion	Carnegie Mellon	W 3-2	29	5667637	W	3	
4	09/06/2024	Westminster (PA)	Carnegie Mellon	L 0-3	517	5668806	L	0	
5	09/07/2024	Scranton	Carnegie Mellon	L 1-3	144	5669175	L	1	

A sample of CMU games in the dataset

Methodology

NPI

Calculation



- Calculate the NPI score
- Rank the teams and determine if CMU make the cut

- Use Elo Rating

- Run Simulation of randomized schedule
- Simplify by only changing CMU schedule
- Predictions on current schedule

Result

- find features of a good schedule
- Create interface for further research

Optimizing Game Schedule for CMU Women's Volleyball Team Presenter: Haichuan Sun, Yilin Du Advisor : Professor Yurko

Simulation

- Use Elo rating to show balance of power and simulate games
- Sample from a bernoulli distribution with p = Expected win for simulated results
- Regress Elo to mean between season due to roster changes



R = Rating, K = Update Factor, S = actual result

$$E_{
m home} = rac{1}{1+10^{(R_{
m away}-R_{
m home})/400}}$$

Expected win formula

 $R_{
m home}^{
m new} = R_{
m home} +$



Median ranking across 50 simulations per schedule



$$K \cdot (S_{ ext{home}} - E_{ ext{home}})$$

Update formula for Elo Rating



Game NPI Formula:

 $ext{Game NPI} = (I[W, L] imes 100 imes ext{win_dial}) + (ext{SOS} imes ext{SOS_dial}) + ext{QWB}$ Where:

• I[W, L] is an indicator function:

$$I(W)=1, \quad I(L)=0$$

- $win_{dial} \in [0,1]$: Win coefficient.
- SOS: Strength of Schedule.
- $SOS_dial \in [0, 1]$: SOS coefficient.
- QWB: Quality Win Bonus (for beating strong teams).

Team NPI Formula:

Team NPI = Weighted Average of Selected Game NPIs where selection of games drops negative wins and positive losses based on the rules





Discussion

- **Deeper Analysis of Wins and Scheduling Impact:** Evaluate which wins are retained under current rules and assess whether running more simulations might affect our evaluation of how favorable or unfavorable a schedule is.
- 2. Better Incorporate Scheduling Regulations: Integrate real-world constraints such as the 500-mile in-region limit, home and away balance, and variations in game days and number of games.
- Enhance the Simulation Algorithm: Improve by modeling UAA tournaments, auto-qualification rules, home vs away effects, score differences, and accounting for opponents' schedules.
- **Expand Optimization Methods to Other Sports:** Apply the same system and optimization techniques across different sports, adjusting for their unique parameters.
- **Develop and Refine the NPI System:** Improve dial settings and parameters, and research whether NPI rankings truly capture team strength accurately.



Accuracy of our NPI Calculation Replication