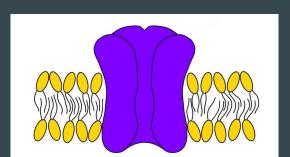
Baseball's Unprecedented Half-innings and Other Insights from Markov Chains

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September 12, 2019



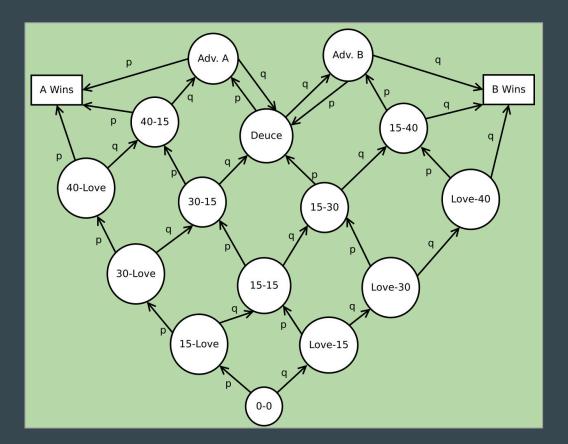






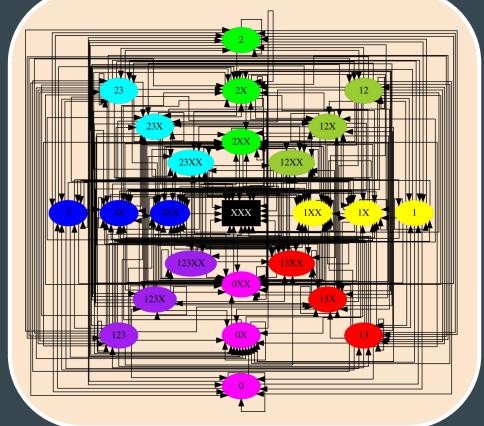
What is a Markov Chain?



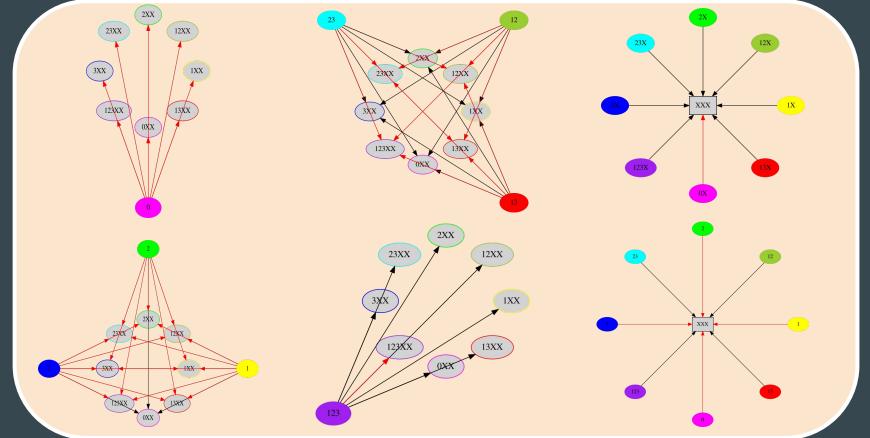


Baseball's Graph as a Markov Chain

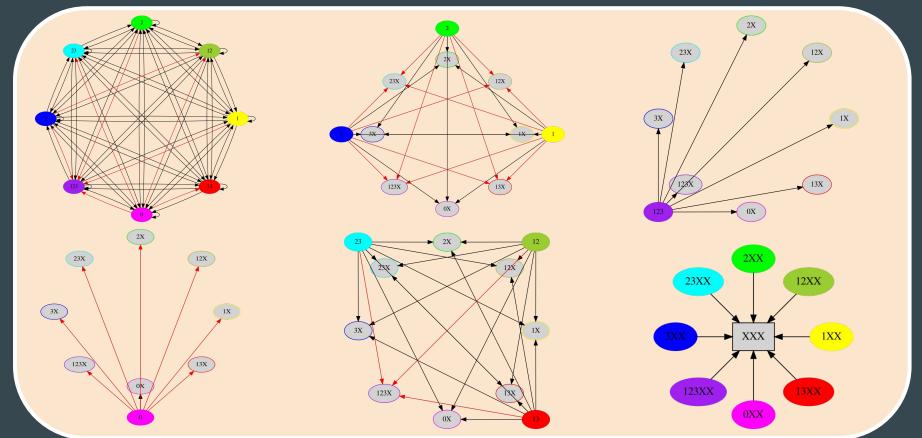




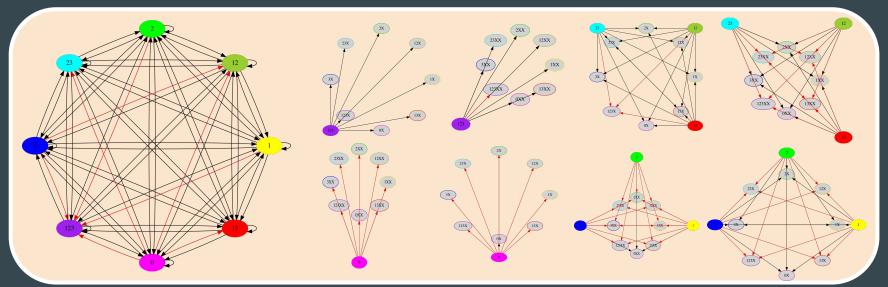
Visualizing Baseball's Graph (Double and Triple Plays)



Visualizing Baseball's Graph (Clean and Single Plays)



Symmetry and Asymmetry in Baseball's Graph



Rules of symmetric & real baseball: \triangle Outs ≥ 0 AND $0 \le \text{Runners-on-base} \le 3$

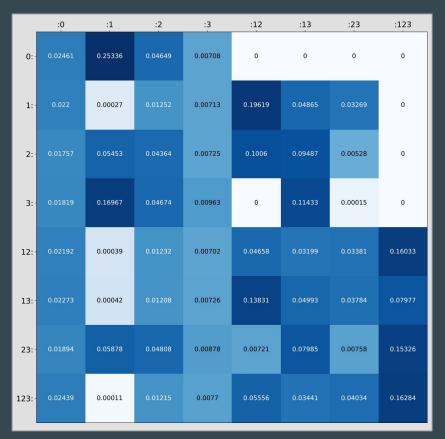
 Δ Runners-on-base = 1 - Δ Outs - Δ Score

 Δ Score ≥ 0

Additional asymmetries in real baseball: Three outs and it's over!

3:12 (3X:12X, ...) impossible---runners cannot retreat!

Transition Probability Matrix -- Clean Plays, No Outs

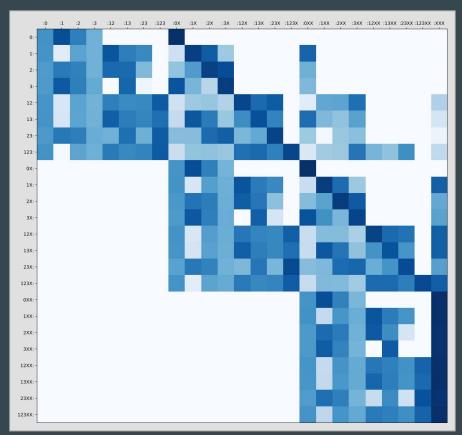


Prob. =
$$\# (\text{From} \rightarrow \text{To})$$

From

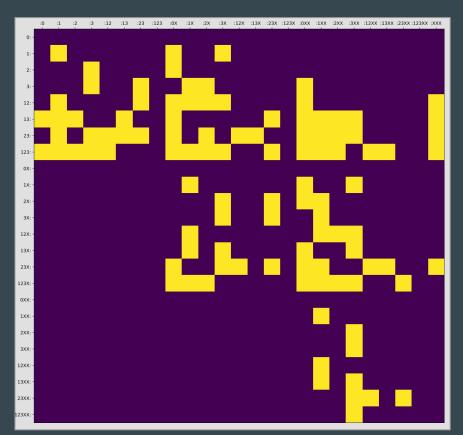
Computed with respect to a population of transitions

Full Transition Probability Matrix



Population: All MLB teams, 1930-2018, Regular season

Many More Probabilities Are Zero for Subpopulations

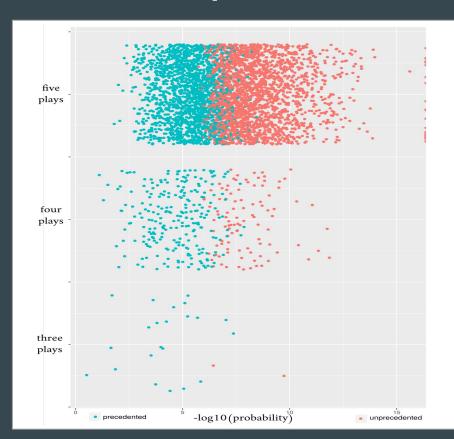




Washington Nationals, batting at home, 2018

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						1:1						12:0XX			123X:1X				
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									12X:3XX			12:3X 12:XXX							
				1X:3XX		1:3X				2:0X		12:1X 12:2X			123X:3XX	13:3X	123:1XX 123:2XX 123:3X	23:0XX 23:2XX	
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	-			1X:2X		1:2	,	2X:1XX	<			12:1XX 13:2X			123X:2X 23X 23X			23:13X	3:3
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Baseball's Unprecedented Half-innings

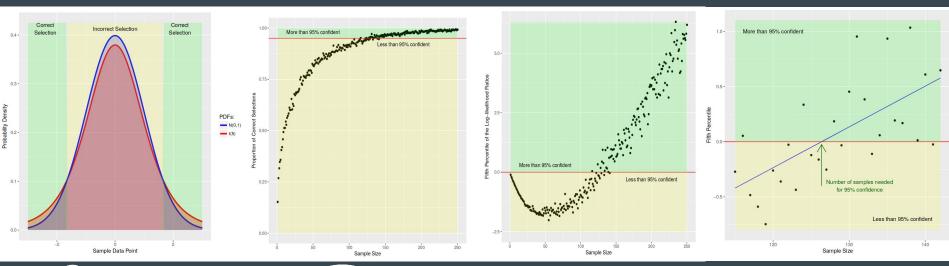


The most unlikely unprecedented half-innings:

```
|-log10(probability)|
sequence
            Three Plays
0:3:13:XXX
                6.43509767499117
0:3:23:XXX
                 9.73543779430501
             Four Plays
0:2:3:23:XXX
                11.0579993507313
0:0:3:23:XXX
                11.3442887847059
0:3:3:23:XXX
                11.7519898723546
0:3:23:23:XXX
                 11.855734799529
             Five Plays
0:3:23:3:23:XXX
                 15.6122744428876
*3XX:23XX*
```

log10(number of half-innings played) = 6.45

Quantifying the Similarity Between Model Baseball Teams





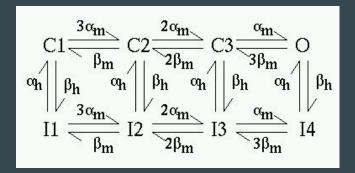


Result: it takes 30±1 half-innings, simulated from the 2011 Baltimore Orioles model, to reject, with 95% confidence, the statement that these half-innings were sampled from the 2011 New York Yankees model.

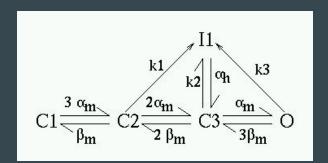
Making Half-inning History and **Markov Transition Probabilities** Easily Accessible to All aws



Beyond Sports



Hodgkin-Huxley Sodium Channel



Modern Model of Sodium Channel

$$C1\frac{\frac{4\alpha_n}{}}{\beta n} C2\frac{\frac{3\alpha_n}{}}{2\beta n} C3\frac{\frac{2\alpha_n}{}}{3\beta n} C4\frac{\frac{\alpha_n}{}}{4\beta n} O$$

Potassium Channel



Exposure Incubation Transmission Immunity

Collaborators on Related Projects



Jacob Ward

Formerly Professorial Lecturer, American University



Jake Berberian

Class of 2022, American University



Kingsley Iyawe

Masters Student, American University, expected graduation: May 2020