Rating, Ranking, Betting and Mathematics

R VITTAL RAO

rvrao@cedt.iisc.ernet.in

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Ed: "Are you alright?"
Mark: "I need you"
Ed: "I am here for you"
Mark: "No, I need your algorithm to rank chess players"

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Ed: “Do you think it is such a good idea?”
Mark: “I need your algorithm - I need your algorithm”
Ed: “With each girl’s base rating 1400...”
Ed proceeds to write the formulae (on a window with a crayon)

Eduardo's Formula!

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$$E_a = \frac{1}{1 + 10^{\frac{(R_b - R_a)}{400}}}$$

Eduardo's Formula!

$$
\begin{aligned}
E_a &= \frac{1}{1 + 10^{\frac{(R_b - R_a)}{400}}} \\
E_b &= \frac{1}{1 + 10^{\frac{(R_a - R_b)}{400}}}
\end{aligned}
$$

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And all those expectations are expressed this way"

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Andrew Garfield as Eduardo Saverin (cofounder)

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Andrew Garfield as Eduardo Saverin (cofounder)
Justin Timblelake as Sean Parker (cofounder)

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RATING and RANKING

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Every Rating creates a Ranking by arranging the ratings in descending order

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Such pairwise comparisons are at the heart of most of the methods of rating and ranking

General Mathematical Techniques

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- Game Theory

ARROW's IMPOSSIBILITY THEOREM

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$$\begin{aligned} r_i &= \frac{1 + k}{2 + 2k} \\ &= \frac{1}{2} \end{aligned}$$

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On June 26, 2012, it was announced that the Bowl Championship Series will be replaced by a four-team playoff, effective for the 2014-15 season to be known as the College Football Playoff.

Elo's Rating

Chess Rating

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$(r_i)_{old}$ is the rating of Player P_i before he plays a game
$(r_i)_{new}$ is the rating of Player P_i after he plays the game
How are $(r_i)_{old}$ and $(r_i)_{new}$ related?

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μ is the mean score of P_i till that time

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For chess games,

$$S = \begin{cases} 1 & \text{if} \quad P_i \text{ wins} \\ \frac{1}{2} & \text{if} \quad P_i \text{ draws} \\ 0 & \text{if} \quad P_i \text{ loses} \end{cases}$$

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Jeff Segarin (USA Today) adapted for American Football

Current Version

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Suppose P_i plays against P_j

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$$S_{ij} = \begin{cases} 1 & \text{if} \quad P_i \text{ beats } P_j \\ \frac{1}{2} & \text{if} \quad \text{game is a draw} \\ 0 & \text{if} \quad P_i \text{ loses} \end{cases}$$

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Suppose P_i plays against P_j

$$S_{ij} = \begin{cases} 1 & \text{if} \quad P_i \text{ beats } P_j \\ \frac{1}{2} & \text{if} \quad \text{game is a draw} \\ 0 & \text{if} \quad P_i \text{ loses} \end{cases}$$

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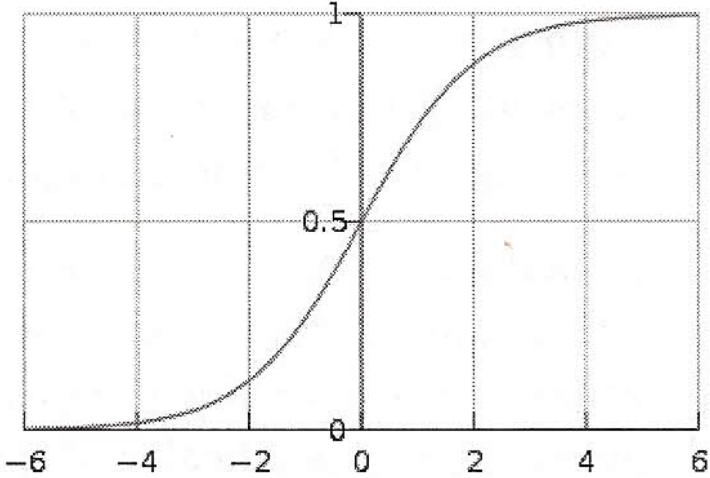
The Logistic Curve $L(x)$



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The K Factor Used For Chess:
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Better Reward For beating stronger Team

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Similarly

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\text{Reward for } T_j &= K\left(1 - \frac{1}{1 + 10^{-\frac{2100-1700}{400}}}\right) \\
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\Longrightarrow & \\
\mu_{ij} + \mu_{ji} &= \frac{1}{1+10^{-\alpha_{ij}}} + \frac{1}{1+10^{\alpha_{ij}}} \\
&= 1
\end{aligned}$$

The Total score is One

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Clearly we have

$$S_{ij} + S_{ji} = 1$$

The Total Rating is Invariant

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If T_i and T_j play then only the ratings of T_i and T_j change after the game depending on the reward they get. Hence

$$\sum_{k=1}^{n}(r_k)_{new} \quad =$$

$$\sum_{k=1}^{n}(r_k)_{new} = \sum_{k\neq i,j}(r_k)new +$$

$$\sum_{k=1}^{n}(r_k)_{new} \quad = \quad \sum_{k\neq i,j}(r_k)new + (r_i)new +$$

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SPREAD BETTING

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He started the new method of trading and changed the way people bet

Beat The Spread

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“BEATING THE SPREAD

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Since the time of McNeil,
"BEATING THE SPREAD
is the HOLY GRAIL of the betting world

What does “Beating the spread mean?

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Suppose the match score is as follows:

- CASE 1: A beats B with score line $58 - 47$

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My Bet on A

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Suppose $\mathcal{I}$ bet on A

My Bet on A

$$\frac{\text{Suppose } \mathcal{I} \text{ bet on } A}{\text{In Case 1, } \mathcal{I} \text{ win the bet because } A \text{ beats } B \text{ by more than 10 Points}}$$

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In Case 1, $\mathcal{I}$ win the bet because A beats B by more than 10 Points

In Case 2, $\mathcal{I}$ lose the bet because even though A beats B it is not by more than 10 Points

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In Case 3, $\mathcal{I}$ lose the bet because A loses to B

My Bet on B

My Bet on B

Suppose I bet on B

My Bet on B

$$\frac{\text{Suppose I bet on } B}{\text{In Case 1 } \mathcal{I} \text{ lose because } A \text{ has beaten } B \text{ by more than 10 points}}$$

My Bet on B

Suppose I bet on B

In Case 1 $\mathcal{I}$ lose because A has beaten B by more than 10 points
In Case 2 $\mathcal{I}$ win because even though B lost he has lost it by less than 10 points

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Suppose I bet on B

In Case 1 $\mathcal{I}$ lose because A has beaten B by more than 10 points
In Case 2 $\mathcal{I}$ win because even though B lost he has lost it by less than 10 points
In Case 3 $\mathcal{I}$ win because anyway B has won

Handling Ties

Handling Ties

To handle ties the book makers usually give the spread as 7.5 or 8.5 etc.

Using the Spread For Rating

The Spread matrix

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The Spread Matrix $\mathcal{S}$:
$\mathcal{S} = (S_{ij})_{n \times n}$ (diagonal entries are defined to be zero)
$\mathcal{S}$ is a SKEW SYMMETRIC MATRIX

The Rating Spread matrix

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$$\mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}$$

be any rating of the teams.

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The Rating Spread Matrix:
$\mathcal{X} = (x_{ij})_{n \times n}$ where $x_{ij} = x_i - x_j$

Ideal Situation

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The best way is to find the error $\mathcal{S} - \mathcal{X}$ and find "the" **x** that minimzes this error

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$$\|\mathcal{S} - \mathcal{R}\| < \|\mathcal{S} - \mathcal{X}\| \text{for any other rating } \mathbf{x} \neq \mathbf{r}$$

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$$\frac{\text{(Total Scores of } T_i \text{ in all games) -(Total opponents' score against } T_i\text{)}}{n}$$

Conclusion

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It is not clear if in real life Mark Zuckerberg used Elo's formula to rate girls at Harvard!

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Only he knows!!

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(Nor rated by heartless mathematicians' formulae!!)

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Beauty and the Beast

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Poets: "Beauty of a girl cannot be ranked"

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Poets: “Beauty of a girl cannot be ranked”
Arrow: “Beastly politicians cannot be ranked”

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