McMaster Phys-dept Squashing: The Ranking System

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The dual-rank system to be employed is described. The algorithms are presented, parameter settings justified, and examples are given1. Lasted updated: May 15, 2024.

TLDR

A rank system will be implemented to quantitatively keep track of players' squash abilities throughout each semester. Only players that have opted-in to this system will be considered, all other players play for fun. These numbers will be public, but may be kept private to themselves (and Billy) upon request. This requires that you relay to Billy the scores of all players for every (ranked) game played from here on out (including games where Billy was not present).

This will be a dual-rank system:

The 'Serious Rank' R_{srs} starts everyone at 1000 points. This number is the competitive one and favors 1-v-1 games rather than King-of-the-Hill games. The winner steals points away from the losing player(s) — the overall number of points is conserved [with potential dissipation (loss in the system), see Section IV].

The 'Fun Rank' R_{fun} starts everyone at 0 points. Players gain points by their placement in each game (1st, 2nd, 3rd) and the score they end with (multiplied by some factor). This system favors the King-of-the-Hill format (as King-of-the-Hill games end on a score of 15 rather than 11) and games played, though a 'points-per-game' value may be indicative of a more competitive value.

In all cases, *every* game contributes to both ranks, so it is expected that there is a mismatch between the two values. The parameters are scaled such that someone winning against similarly matched players for a full hour gains 100 points, and that going against someone 250 R_{srs} pts higher gains $\sim$ 185 pts and going against someone 250 pts lower gains $\sim$ 15 pts.

I. INTRODUCTION

The rapid growth of the squash community in the McMaster physics department is unsettling. During its early stages, the hierarchy of each player's skill was computable on the spot and match-making (choosing which players to go in which courts against who else). A qualitative measure of this is kept in Billy's head, but the rapid skill development, increase in number of players, and the quick-draw necessity of court assignment on the spot warrants a quantitative measure.

We then propose a rank system, a number that gives someone a relative understanding of their squash skill level in comparison to t heir peers. After discussing this idea with a few of those that this would be implemented to, a few thoughts were popular and shared:

- Such a rank system would make our squashing too competitive, which disinterests some.
- Points should be taken into account, that is someone losing a king-of-the-hill with 11 points (to 15) should be rewarded more compared to losing with 3 points.
- Self-reporting and self-book-keeping is something that may not be reliable.
- It would disincentivize higher-ranked players from playing against lower-ranked players.
- There shall be days where games matter towards the ranks and days where they do not (practice days).

II. THE ALGORITHM(S)

A. Serious Rank

This system mimics the Chess ranking system and is adapted to allow for King-of-the-Hill (> 2 players) games to contribute (see Wiki link). It boils down to a change in rank after each game via

$$\Delta R_{srs} = \frac{K}{1+\exp\left(\dfrac{(R_{srs,\text{loser}} - R_{srs,\text{winner}})}{\sigma}\right)} \ . \quad (1)$$

K controls how much R_{srs} is worth each game and σ control the expectation of the match-up given the two players' R_{srs} going into the game. Then (explicitly)

$$R_{srs,\text{winner, new}} = R_{srs,\text{winner, old}} + \Delta R_{srs} \ ,$$
$$R_{srs,\text{loser, new}} = R_{srs,\text{loser, old}} - \Delta R_{srs} \ .$$

Setting $K = 200/\tau$ and $\sigma = 100$ as an example, see Figure 1 for an example of its behaviour. τ is the expected

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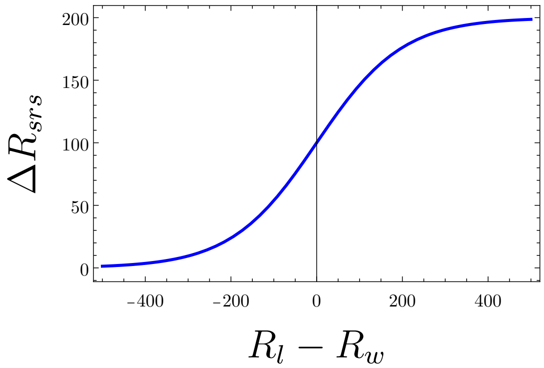

FIG. 1. Plot of equation (1) for $K = 200$, $\sigma = 100$. We see that if a player wins against someone 250 [rank units] higher, they stand to gain $\sim$ 185 rank points (and $\sim$ 15 conversely) with a nice logistic distribution in betwewn.

number of games played in an hour ($\tau = 5$ for 1-v-1's, as 1-v-1's typically take between 5 and 10 minutes). However, we will encode adjustments to this algorithm for games with more than 2 players via the K parameter.

When it comes to games with more than 2 players (King-of-the-Hill), we realize that the score required to win is different. Compared to a game to 11, a winner of a 3-person King-of-the-Hill match only needs an average of 7.5 rallies won from their other two opponents. Similarly, increasing the court capacity to a 4-person game, a winner only needs to win 5 rallies against each opponent. As such, we define K for N players on a court:

$$K \equiv \frac{K_0}{(N-1)^2 \cdot \tau} \quad , \quad \sigma = \sigma_0 \ , \tag{2}$$

(see Appendix A for determination of $K_0 = 250$ and $\sigma_0 = 250$) where

$$\tau = \begin{cases} 5 & \text{if } N = 2 \ , \\ 4 & \text{if } N > 2 \ . \end{cases} \ . \tag{3}$$

The inverse square relation to number of players reflects this King-of-the-Hill difference. The harsher choice of the square (instead of a inverse-linear relation) puts the emphasis on R_{srs} being a match-winning (1-v-1) indicative rank while allowing a fraction to be gained in the different dynamic of a King-of-the-Hill game.

For calculations of ΔR_{srs} when $N > 2$, the rank points interaction is that of charged particles with regards to Colomb's law — that is the superposition of them. For example, if player A wins a King-of-the-Hill against player B and C (respectively, that is B comes second and C third), then

$$\begin{aligned} R_{A,\text{new}} &= R_A + \Delta R_{AB} + \Delta R_{AC} + (\Delta R_{AD}) \ , \\ R_{B,\text{new}} &= R_B - \Delta R_{AB} + \Delta R_{BC} + (\Delta R_{BD}) \ , \\ R_{C,\text{new}} &= R_C - \Delta R_{AC} - \Delta R_{BC} + (\Delta R_{CD}) \ . \\ (R_{D,\text{new}} &= R_D - \Delta R_{AD} - \Delta R_{BD} - \Delta R_{CD} \ .) \\ &\cdots \end{aligned}$$

In the case of a tie between the non-winners, $\Delta R = 0$.

Everyone starts at $R_{srs} = 1000$ once opted in and this rank is reset at the beginning of every semester, though a record of a lifetime R_{srs} and $R_{srs,highest}$ is kept and may be called via a message to Billy. The only time there is an increase to the overall bank of R_{srs} is when a new player opts-in to the system, the only time there is a decrease in the overall bank is through rank decay (see Section IV), otherwise all players fight for a fixed amount of R_{srs} points for a decisive leaderboard at the end of the semester.

B. Fun Rank

This system mimics the APEX Legends' (a Battle-Royale video game) rank system. After it all, one gains points based on their placement in a game (1st, 2nd, 3rd) along with their score multiplied by some factor. These factors are higher the higher placement one achieves but also accounts for rank differences.

That is

$$\Delta R_{fun} = \frac{\mathcal{P} + [score] \cdot \phi \cdot \psi}{\tau} \ , \tag{4}$$

where τ is defined in (3) and

Placement	$\mathcal{P}$	ϕ
1st	55	3
2nd	44	2.5
3rd	40	2
4th	25	1
5th	0	0

$\mathcal{R}_i$	ψ	
+750 to ∞	0.30	
+500 to +750	0.70	
+250 to +500	1.00	
$\pm$250	1.00	
-250 to -500	1.50	
-500 to -750	2.00	
-750 to $-\infty$	3.00	

where

$$\mathcal{R}_i = \begin{cases} (R_{fun,\text{winner}} - R_{fun,\text{last place}}) & \text{if } i = \text{winner} \ , \\ (R_{fun,i} - R_{fun,\text{winner}}) & \text{if } i \neq \text{winner} \ . \end{cases} \tag{5}$$

The parameters set in table reflects the safety configuration distribution, that is 3-players is optimally safe, 4-players pushes the boundary, and 5-players should be avoided. There are methods to assuage the effect of ψ (see III).

This the overall R_{fun} in the system diverges as number of games increases. This is by design. This rank is meant to reflect the experience (# of games) and progress (score won each game) of a player, hence the 'fun'.

All opted-in players start at $R_{fun} = 0$ which is reset to $R_{fun} = 0$ at the beginning of each semester with a record kept $R_{fun,\text{lifetime}}$. The score published will be an absolute R_{fun} as well as a useful ratio R_{fun}/game.

III. THE HANDICAP™

An optional (handicapping) rule set is introduced to allow for players to i) play a more balanced game against a much stronger player, ii) play a more fruitful game (longer rallies, easier shots to make, more chances to learn and improve) while allowing the handicapped player to work on aspects of the game they have neglected, and iii.) allow highly ranked players to still gain a non-trivial amount of rank points by winning games.

Winning with the handicap sets $R_{srs,\text{loser}} - R_{srs,\text{winner}} = 0$ and $\psi = 1.0$, while losing with the handicap calculates $R_{srs,\text{loser}} - R_{srs,\text{winner}}$ normally but still $\psi = 1.0$.

The rules are as follows: squash rules are the same, with the exception that the Handicap™'ed player's new 'out' lines are changed.

- The bottom 'out' line (the tin on the wall) is now the middle line on the wall (used for serves).

- The back top 'out' line is now either the back of the serving (small) box *or* the back wall (as in the ball is considered out if the ball hits the back wall before bouncing off the floor). The choice between the two is decided solely at the Handicap™'ed player's discretion at the beginning of the game and cannot be changed during the game.

IV. RANK DECAY/RECOVERY

Upon 3 weeks of inactivity, players' R_{srs} ranks will decay (or recover back up towards 1000), compounded weekly. The loss (gain) is calculated:

$$\delta R_{srs} = -\frac{R_{srs} - 1000}{6} \ . \tag{6}$$

This choice gives a decaying exponential asymptotically approaching 1000, that is $\frac{\mathrm{d}}{\mathrm{d}t} R_{srs}(t) = -\dfrac{R_{srs}(t) - 1000}{6}$ gives the solution $R_{srs} = C \cdot \exp(-s/6) + 1000$ for some integration constant C determined by the rank before the inactivity. Explicitly,

$$R_{srs,\text{new (inactive)}} = R_{srs,\text{old (inactive)}} + \delta R_{srs}$$

is calculated each week.

There is no inactivity punishment for R_{fun}.

V. DISCUSSION ON R_{srs} AND R_{fun}

(Referring to results shown in Appendix A) After thorough testing using uniformly (that is all players performed evenly) and biased (one player performs superbly better) generated samples, It is shown that

A contemplation considered when these ranks were in the 'just an idea' phase was that in making such a system, our squashing routines would be

VI. FAQ

None yet. . . .

Appendix A: Examples

We generate a set of pure 1-v-1 junkies (100 games) and pure 3-person King-of-the-Hill sans (72 games). The number of games reflects the expected amount for the rest of the spring/summer term. For a 3-person King-of-the-Hill, expect 6 ranked games per week 6×4 weeks $\times\, 3$ months $= 72$. For a 1-v-1, expect approximately 8 ranked games per week 8×4 weeks $\times\, 3$ months $= 96$ rounds up to 100 as astronomers do.

The score set is generated via a random number generator sampling from i) a uniform distribution and then ii) a normal distribution. The mean and deviation of the biased normal distribution is set such that one of the players wins approximately 75% of the time while the non-winners still have a nonzero score (also randomly generated).

1. 1-v-1 people

a. Random

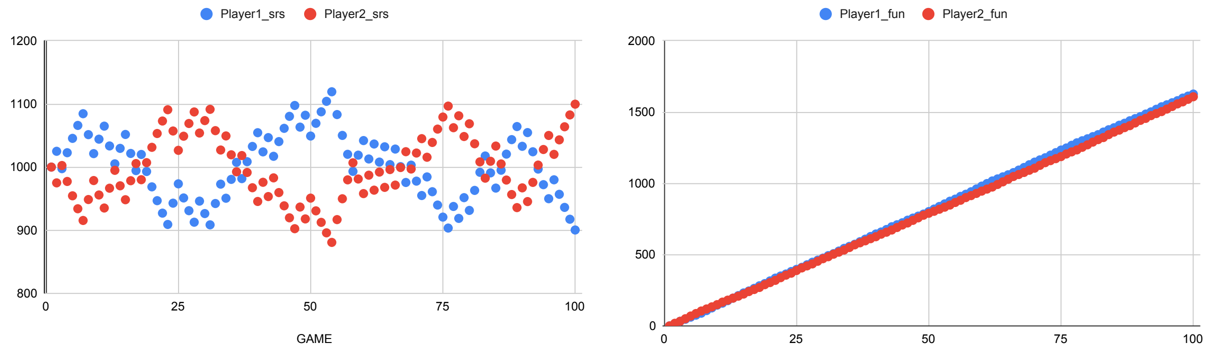

FIG. 2. Winrate: 50-50

b. Biased

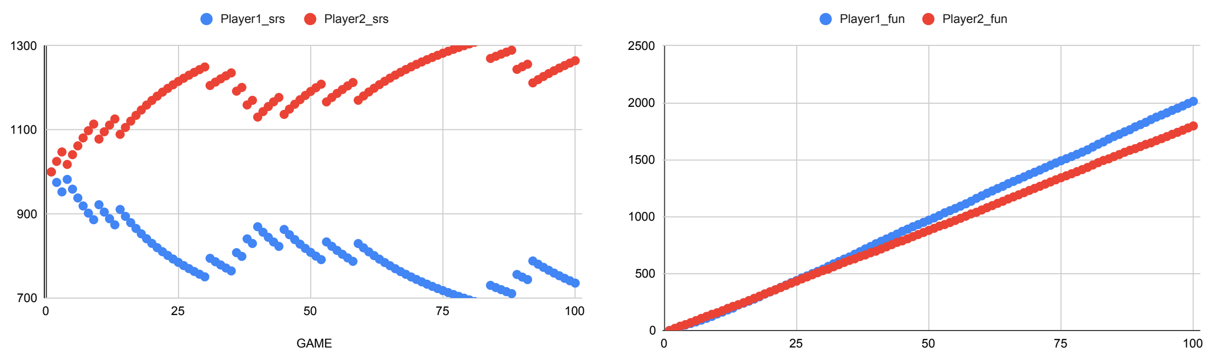

FIG. 3. Winrate: 76-24

2. King-of-the-Hill people

a. Random

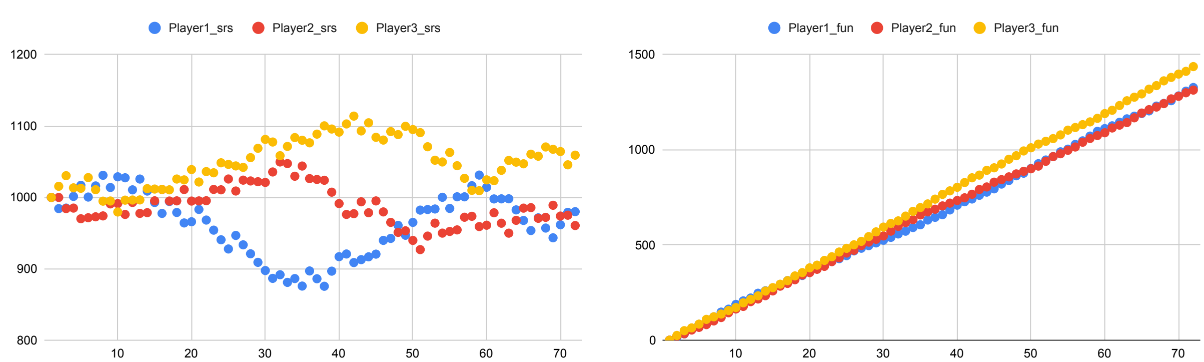

FIG. 4. Winrate: 34.7-29.2-36.1

b. Biased

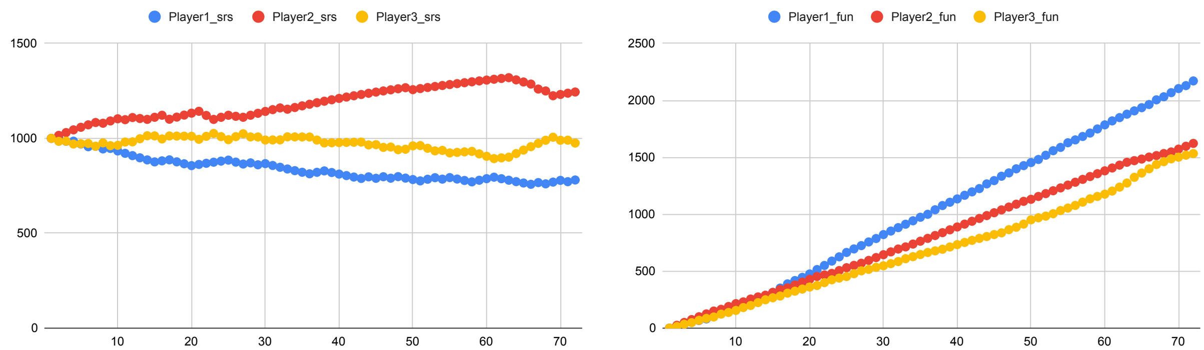

FIG. 5. Winrate: 0-68-32

Appendix B: The Code

To be updated...