

Skill Inference and Chess Cheating Detection from Big Data

Cornell University Applied Math Colloquium

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¹Includes joint work with Guy Haworth and GM Bartłomiej Macieja. Sites:
<http://www.cse.buffalo.edu/~regan/chess/fidelity/> (my homepage links),
<http://www.cse.buffalo.edu/~regan/chess/ratings/> (not yet linked)

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- 6 Derived Outputs:
 - Aggregate statistics: *move-match* MM, *average error* AE, ...
 - Projected confidence intervals for those statistics.
 - “Intrinsic Performance Ratings” (IPR’s).

Main Principle and Schematic Equation

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- Needs **Multi-PV** analysis—already beyond Guid-Bratko work.
- **Single-PV** data on millions of moves shows other improvements.

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 - Choice of fitting methods
- 3 Scientific discovery beyond original intent of model.
 - Human tendencies (different from machine tendencies...)
 - Follow simple laws...

Better, and Best?

Need a general function f and a function $\delta(i)$ giving a *scaled-down* difference in value from m_1 to m_i .

$$\frac{f(\Pr_E(m_i))}{f(\Pr_E(m_1))} = g(E, \delta(i)).$$

Implemented with $f = \log$ and **log-log scaling**, as guided by the data.

Best model? Let *weights* w_d at different *engine depths* d reflect a player's depth of calculation. Apply above equation to evals at each depth d to define $\Pr_E(m_i, d)$. Then define:

$$\Pr_E(m_i) = \sum_d w_d \cdot \Pr_E(m_i, d).$$

This accounts for moves that *swing* in value and idea that weaker players prefer weaker moves. **In Process Now.**

Why Desire Probabilities?

- Allows to *predict* the # N of agreements with any sequence of moves m_*^t over game turns t , not just computer's first choices:

$$N = \sum_t \Pr_E(m_*^t).$$

- **and** it gives **confidence intervals** for N .
- Also predicts *aggregate error* (AE, scaled) by

$$e = \sum_t \sum_i \delta(i) \cdot \Pr_E(m_i^t).$$

Comparing e with the *actual* error e' by a player over the same turns leads to a “virtual Elo rating” E' for those moves.

- **IPR** \equiv “Intrinsic Performance Rating.”

The Turing Pandolfini?

- **Bruce Pandolfini** — played by Ben Kingsley in “Searching for Bobby Fischer.”
- 25th in line for throne of Monaco.
- Now does “**Solitaire Chess**” for Chess Life magazine:
 - Reader covers gamescore, tries to guess each move by one side.
 - E.g. score 6 pts. if you found 15.Re1, 4 pts. for 15.h3, 1 pt. for premature 15.Ng5.
 - Add points at end: say 150=GM, 140=IM, 120=Master, 80 = 1800 player, etc.
- Is it scientific?
- With my formulas, **yes**—using *your* games in *real* tournaments.

Judgment By Your Peers

Training Sets: **Multi-PV** analyze games with both players rated:

- 2690–2710, in 2006–2009 and 1991–1994
- 2590–2610, "" "", extended to 2580–2620 in 1976–1979
- 2490–2510, all three times
- 2390–2410, (lower sets have over 20,000 moves)
- 2290–2310, (all sets elim. moves 1–8, moves in repetitions,
- 2190–2210, (and moves with one side > 3 pawns ahead)
- Down to 1590–1610 for years 2006–2009 only.
- 2600-level set done for all years since 1971.

Training the Parameters

- Formula $g(E; \delta)$ is really

$$g(s, c; \delta) = \frac{1}{e^{x^c}} \quad \text{where} \quad x = \frac{\delta}{s}.$$

- s for *Sensitivity*: smaller $s \equiv$ better ability to sense small differences in value.
- c for *Consistency*: higher c reduces probability of high- δ moves (i.e., blunders).
- Full model will have parameter d for depth of calculation.

Fitting and Fighting Parameters

- For each Elo E training set, find (s, c) giving best fit.
- Can use many different fitting methods...
 - Can compare methods...
 - Whole separate topic...
 - Max-Likelihood does *poorly*.
- Often s and c trade off badly, but $E' \sim e(s, c)$ condenses into one Elo.
- **Strong linear fit**—suggests Elo mainly influenced by error.

Some IPRs—Historical and Current

- Magnus Carlsen:
 - 2983 at London 2011 (Kramnik 2857, Aronian 2838, Nakamura only 2452).
 - 2855 at Biel 2012.
- Bobby Fischer:
 - 2921 over all 3 Candidates' Matches in 1971.
 - 2650 vs. Spassky in 1972 (Spassky 2643).
 - 2724 vs. Spassky in 1992 (Spassky 2659).
- Hou Yifan: 2971 vs. Humpy Honeru (2683) in Nov. 2011.
- Paul Morphy: 2344 in 59 most imp. games, 2124 vs. Anderssen.
- Capablanca: 2936 at New York 1927.
- Alekhine: 2812 in 1927 WC match over Capa (2730).
- Simen Agdestein: 2586 (wtd.) at Hoogeveens 1988.

Sebastien Feller Cheating Case

- Khanty-Mansiysk Olympiad 2010: Feller played 9 games (6-1-2, board 5 gold).
- Cyril Marzolo confessed 4/2012 to cheating most moves of 4 games. On those 71 moves:
 - Predicted match% to Rybka 3 depth 13: $60.1\% \pm 10.7\%$
 - Actual: 71.8%, z -score 2.18 (Barely significant: rumor says he used Firebird engine.)
 - AE test more significant: $z = 3.37$ sigmas.
 - IPR on those moves: **3240**.
- On the other 5 games: actual < predicted, IPR = **2547**.
- Paris Intl. Ch., July 2010: **3.15** sigmas over 197 moves, IPR **3030**.
- Biel MTO, July 2010: **no** significant deviation, alleged cheating on last-round game only.

What is a Scientific Control?

- If I say odds are 2,000-to-1 against Feller's performance being "by chance," then I should be able to show 2,000 other players who did not match the computer as much.
- (show "Control" site on Internet)
- But note—if I have many more performances, say over 20,000, then I **should** expect to see higher match % by **non-cheating** players! **"Littlewood's Law"**
- (show)
- To be sure, stats must combine with other evidence.
- (show "Parable of the Golfers" page)
- *Aside from cheating, what does this tell us about humanity?*

1. Perception Proportional to Benefit

How strongly do you perceive a difference of 10 kronor, if:

- You are buying lunch and a drink in a pub. (100 Kr)
- You are buying dinner in a restaurant. (400 Kr)
- You are buying an I-pod. (1000 Kr)
- You are buying a car. (100,000 Kr)

For the car, maybe you don't care. In other cases, would you be equally thrifty?

*If you spend the way you play chess, you care maybe
4× as much in the pub!*

(show pages)

2. Is Savielly Tartakover Right?

The winner is the player who makes the next-to-last blunder.

- We like to think chess is about **Deep Strategy**.
- This helps, but is it **statistically dominated** by blunders?
- Recent Examples:
 - USA-Russia and USA-China matches at 2012 Olympiad.
 - Gelfand-Anand 2012 Rapid playoff.
- My **Average Error** (AE) stat shows a tight linear fit to Elo rating.
- Full investigation will need ANOVA (analysis of variance).

3. Procrastination...

- (Show graph of AE climbing to Move 40, then falling.)
- Aug. 2012 *New In Chess*, Kramnik-Grischuk, Moscow Tal Mem.
 - King's Indian: 12. Bf3!? then 13. Bg2 N (novelty)
 - "Grischuk was already in some time pressure."
- IPR for Astana World Blitz (cat. 19, 2715) **2135**.
- IPR for Amber 2010+2011 (cat. 20+21): **2545**.
- Can players be coached to play like the young Anand?

4. Human Skill Increasing Over Time?

- In 1970s, **two** 2700+ players: Fischer and Karpov. In 1981: none!
- Sep. 2012 list, **44** 2700+ players. **Rating Inflation?**
- My results:
- 1976–1979 vs. 1991–1994 vs. 2006–2009: Little or no difference in IPR at all rating levels.
- 2600 level, 1971–present:
 - Can argue 30-pt. IPR difference between 1980's and now.
 - Difference measured at 16 pts. using 4-yr. moving averages, 10-year blocks.
 - Explainable by faster time controls, no adjournments?
- Single-PV AE stat in all Cat 11+ RRs since 1971 hints at mild **deflation**.
- Moves 17–32 show similar results. Hence not just due to better opening prep?
- Increasing skill consistent with Olympics results.

5. Variance in Performance, and Motivation?

- Let's say I am 2400 facing 2600 player.
- My expectation is 25%. Maybe:
 - 60% win for stronger player.
 - 30% draw.
 - 10% chance of win for me.
- In 12-game match, maybe **under 1%** chance of winning **if we are random**.
- But my model's intrinsic error bars are often **200 points wide** over 9–12 games.
- Suggests to take **event** not **game** as the unit.
- How can we be motivated for events? (show examples)

6. Are We Reliable?

- One blunder in 200 moves can “ruin” a tournament.
- But we were reliable 99.5% of the time.
- Exponential $g(s, c)$ curve fits better than inverse-poly ones.
- Contrary to my “Black Swan” expectation.
- But we are even more reliable if we can use a computer...
- (show PAL/CSS Freestyle stats if time).

7. Not Just About Chess?

- *Only chess aspect of entire work is the evaluations coming from chess engines.*
- No special chess-knowledge, no “style” (except as reflected in fitted s, c, d).
- General Problem: **Converting Utilities Into Probabilities** for *colordarkredfallible agents*.
- Framework applies to **multiple-choice tests**, now prevalent in online courses.
- Alternative to current psychometric measures?
- Issue: Idea of “best move” at chess is the same for all human players, but “best move” in sports may depend on natural talent.

Conclusions

- Lots more to do!
- Can use helpers!
 - Run data with other engines, such as **Stockfish**.
 - Run more tournaments.
 - Run to higher depths—how much does that matter?
- Spread word about general-scientific aspects; fight gullibility and paranoia over cheating.
- Deter cheating too.
- Learn more about human decision making.
- Thus the Turing Tour comes back to the human mind.
- **Thank you very much for the invitation.**