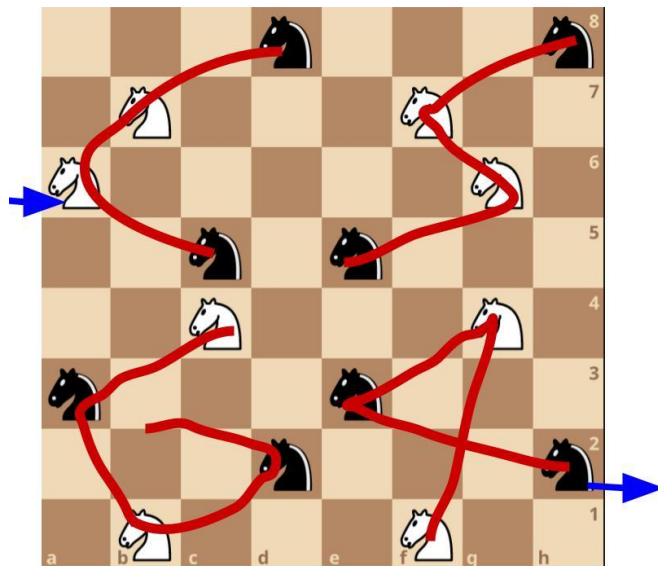A mysterious scammer challenges 10 chess grandmasters to 10 simultaneous (asynchronous) games. The scammer will play White in half the games and Black in the others.

The scammer claims they will **win or draw at least ½ of the games.**

Can you figure out how is this possible to pull off, *even if the scammer is not any good at chess?*

CS64: Computation for Puzzles and Games

Autumn 2022
Lecture 2: Chess

Answer to the puzzle

- The scammer can **play the grandmasters against each other!**

- Consider one pair of boards in which the scammer is White on one board (board W) and Black on the other (board B):
  - wait for the opponent on board B to move
  - copy that move onto board W
  - wait for the opponent on board W to move
  - copy that move onto board B...
- ...so the scammer is just relaying moves! This sort of thing is known as a *man-in-the-middle attack* in cryptography.

- It's guaranteed that either one of these two boards will produce a win for the scammer, or that there will be a draw.

The Carlsen-Niemann incidents

- September 4, 2022: Relative upstart Hans Niemann defeats current champion Magnus Carlsen in a live match while playing Black. Carlsen uses an unusual opening, which Niemann claims to have capitalized on.

- September 19, 2022: Facing off against Niemann in a different (online) tournament, Carlsen (petulantly? righteously?) resigns after one move.

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- Later:
  - Niemann admits to having cheated online before, but perhaps understates the frequency.
  - The court of Internet opinion advances its theories (e.g., receiving moves as signals via anal beads)

I always assumed it would be some visual HUD

like this, but for chess

Can it be done?

- Is wearable tech actually good enough for this?

  - I asked a friend of mine who knows systems / embedded stuff. His thought: Probably?

  - One-way: an outside confederate watches the game, uses an AI to find the best move, transmits it

  - Two-way (e.g., when the game is on a tape delay): the player has to transmit the moves to the confederate first

- **How much information** (e.g., how many bits) would you need to be able to transmit to convey a chess move?

Representing moves

- One simple idea: give the starting and ending squares of the move.

  - There are 64 squares, so it takes $\log_2 64$ = 6 bits to represent one... e.g. 101 011 could be column 5, row 3

  - So, a total of 12 bits to represent both the start and end

  - So maybe the subcutaneous implant in your left foot vibrates for a 1, and the one in your right foot vibrates for a 0...

Representing moves

- A better idea? Use the standard algebraic chess notation…

- …but then how to efficiently send letters, numbers, and symbols?
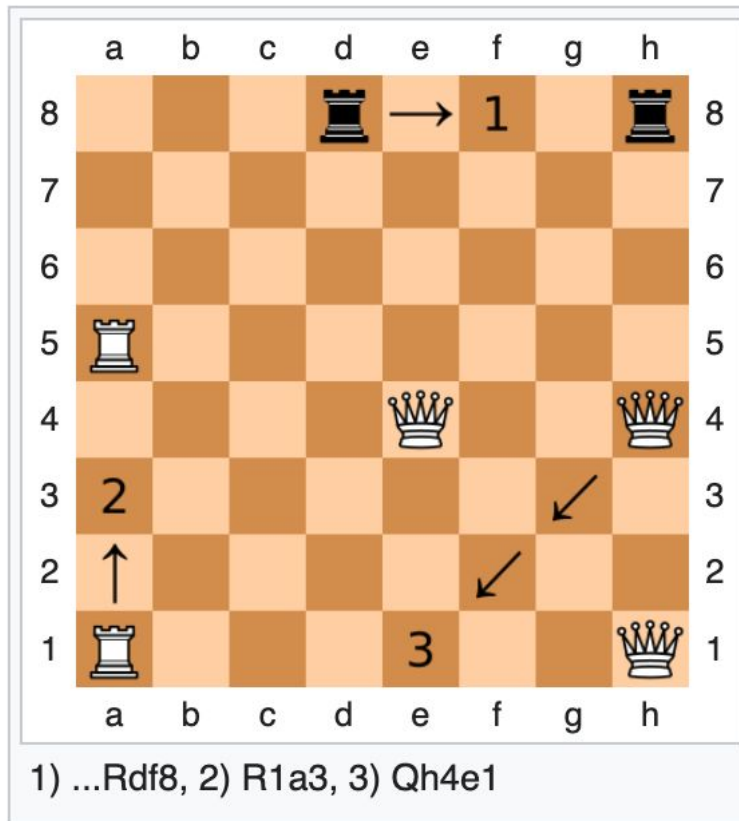
1) …Rdf8, 2) R1a3, 3) Qh4e1

It *has* been done

In 2015, a chess player received signals from a confederate outside the game:

- "But most suspicious of all, he always had his arms folded with his thumb under his armpit. He never took it out."

- "batting his eyelids in the most unnatural way"… "He was deciphering signals in Morse code."

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Tournament organisers then asked the 37-year old to pass through a metal detector and a pendant was found hanging around his neck underneath a shirt that contained **a tiny video camera** as well as **a mass of wires attached to his body** and **a 4cm box under his armpit**.

https://www.smh.com.au/technology/chess-cheat-arcangelo-ricciardi-caught-using-morse-code-underarm-device-20150908-gjhia2.html

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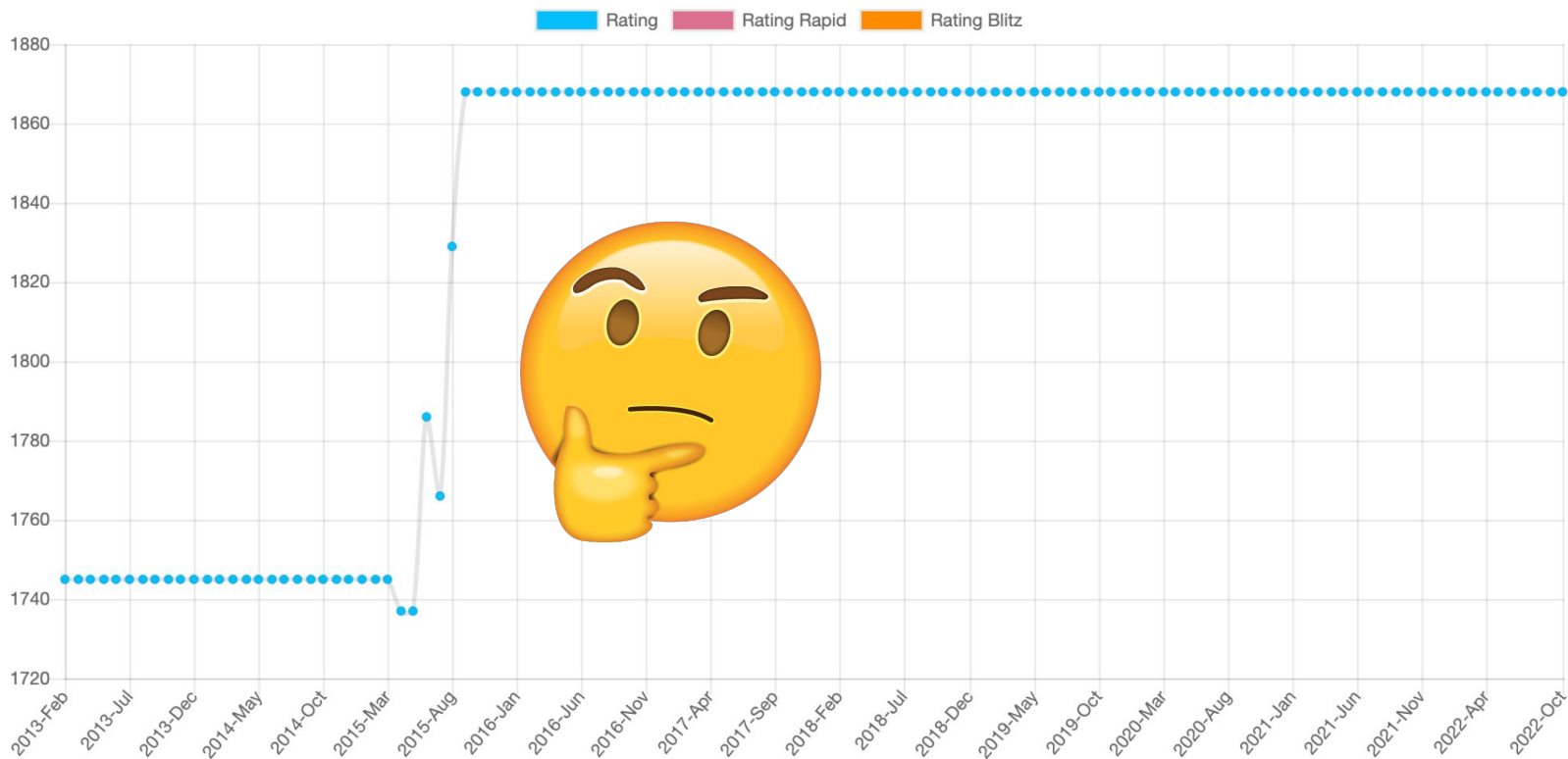In 2015, a chess player received signals from a confederate outside the game:

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Ricciardi claimed they were good luck charms.

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This player's ratings over time

It's maybe even worse in bridge?

- Partners are not *supposed* to be able to communicate except by making declarations and playing cards

- Elaborate rules exist to try to prevent the transmission of additional information…

B. Extraneous Information from Partner

1. Any extraneous information from partner that might suggest a call or play is unauthorized. This includes remarks, questions, replies to questions, unexpected alerts or failures to alert, unmistakable hesitation, unwonted speed, special emphasis, tone, gesture, movement or mannerism.

It's maybe even worse in bridge?

missed. Sure enough, she noticed something odd: when Fantoni and Nunes played a card in certain situations, they sometimes placed it on the table horizontally, and sometimes vertically. She shared her observation with Boye Brogeland, a Norwegian professional player, who has been instrumental in exposing prominent cheaters. An ad-hoc team of expert players quickly cracked the code: in eighty-two of eighty-five instances, they determined, Fantoni and Nunes placed a card on the table vertically when their hands contained an unseen ace, king, or queen of the same suit, or when their hands contained no other card of the same suit; otherwise, they placed it horizontally. (Fantoni and

Some inconclusive thoughts on cheating

- If you can imagine a form of cheating, it is probably already happening at least somewhat, *even if the stakes are not high*

- Games are founded on mutual good faith – cheating can't be completely prevented via rules and penalties

  - and "proving" cheating beyond a reasonable doubt is very difficult (also generally horrible for everyone involved)

  - sometimes some forms of cheating are a tacitly accepted part of the game regardless of what the rules say (baseball)

- It is often worth looking at how other top players react (or don't react) – are *they* giving the accused the benefit of the doubt?

Chess AIs

Change piece colors

# Chess AIs

Deep Blue defeats Kasparov (1997)

- Kasparov had beaten an earlier version of Deep Blue in 1996

- First win by a computer in a serious chess setting

- Perhaps seems quaint and inevitable now but was framed as a momentous step for computers at the time (similar event later on: AlphaGo vs. Lee Sedol in 2016)

State space complexity (here given as $\log_{10}$)

- Tic-Tac-Toe: 3
- Two-player Chutes and Ladders: 4
- Connect Four: 13
- Mancala: 13
- Checkers: 18–20
- Rubik's Cube: 20
- Xiangqi: 40; **Chess: 44**; Shogi: 71
- Thurn and Taxis: 66
- Stratego: 115
- Go: 170

Perhaps a reasonable proxy / lower bound for complexity, but maybe not the whole story (need to know how much branching the game tree has, etc.)

https://en.wikipedia.org/wiki/Game_complexity
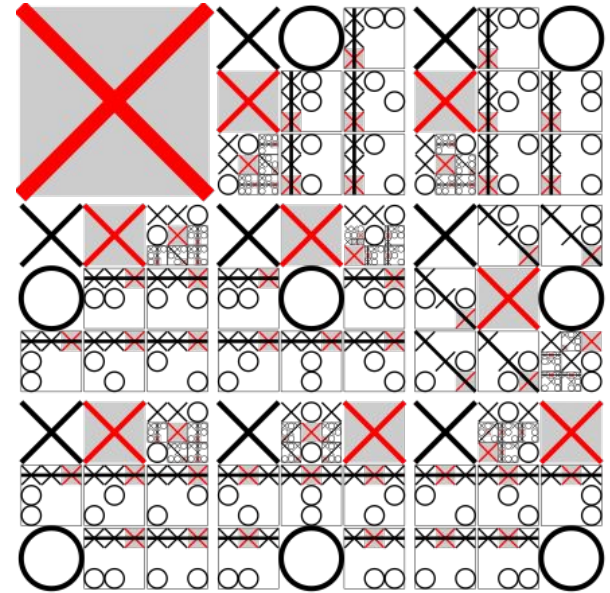
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People also ask ⋮

What is the game with the biggest space?

1/19 Call Of Duty: Black Ops Cold War – 250 GB

an unhelpful Google response… or is it secretly very helpful? Think how huge the state space is in video games

https://en.wikipedia.org/wiki/Game_complexity

Current state of chess AIs

- Humans are doomed

- There are **two** similarly strong chess AIs right now, and surprisingly, they use somewhat different methods!

  - **Stockfish:** better at **search**; uses, e.g. alpha-beta pruning, chess-specific optimizations, some machine learning to evaluate moves

  - **Leela:** Monte Carlo search, better at (ML-based) **evaluation**

Leela is not actually named after this Leela.

# Stockfish's alpha-beta pruning, in words

- Suppose I am choosing my next move, and I have options A, B, C... . I want to evaluate them all and pick the best one.

- Also suppose that I've already fully evaluated option A and found it is *decent but not great.*

Stockfish's alpha-beta pruning, in words

- Suppose I am choosing my next move, and I have options A, B, C... . I want to evaluate them all and pick the best one. Also suppose that I've already fully evaluated option A and found it is *decent but not great.*

- Now I start evaluating option B, which entails considering every possible response the opponent can make. I do this for a while and then realize that the opponent has one response that puts me in a bad situation (worse than "decent but not great" of option A).

  - Now why even bother continuing to evaluate option B, since we know A is better? Just discard option B and move on.

- Other forms of pruning exist too (e.g., forward pruning)

Leela's Monte Carlo tree search, in words

- Randomly sample the search space and identify promising moves
  - Note: just like in our Scrabble discussion, the AI looks several moves ahead!

- Bias search deeply toward promising moves (exploitation) while also making sure to keep looking broadly for unconsidered options that might be even better (exploration)

- Take CS168 to do this with QWOP!
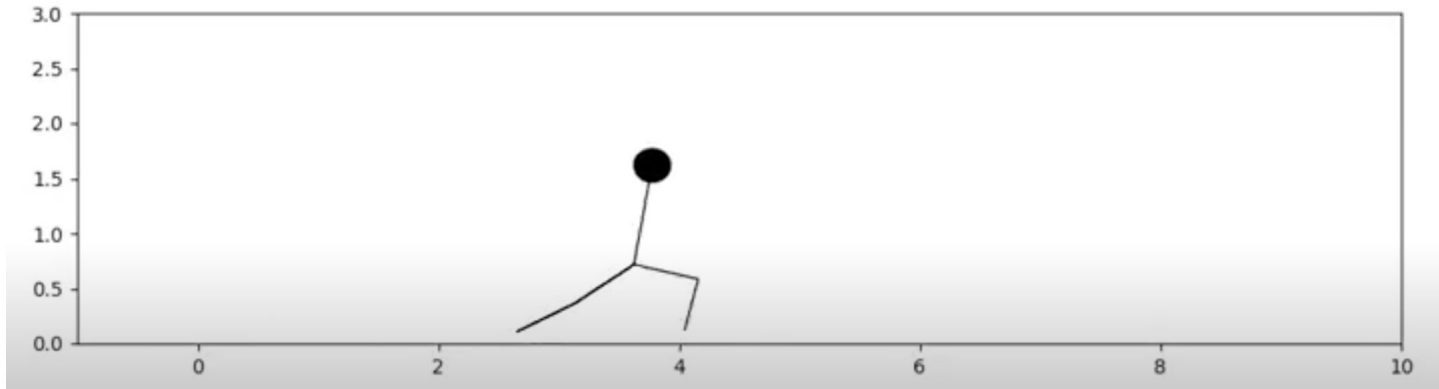
How do you evaluate a move?

- Classic: consider all ways the opponent could respond to make things worst for you, then what you can do in response to that to make things worst for them, etc. (minimax)

- When the tree is too deep for exhaustive search: can still get some estimate of how good states are
  - take a lot of self-play and learn which states are associated (directly or even distantly) with more wins, via lots of linear algebra
  - better yet, infer the common characteristics of those states

- Neural networks are partly learning underlying phenomena about what makes some states better, and also partly just memorizing a lot of specific states

Stockfish vs Leela exemplifies a trend

Old world: Domain experts choose useful features for a model (e.g., number of pawns advanced), make lots of domain-specific optimizations and continue to refine edge and corner cases.

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Old world: Domain experts choose useful features for a model (e.g., number of pawns advanced), make lots of domain-specific optimizations and continue to refine edge and corner cases

New world: *just throw it into a neural network lol*

- The ancestor of Leela (AlphaZero) kinda didn't know it was playing chess! (i.e. the neural network had no chess-specific content, and the researchers fed in the board position and enforced the rules

- Reached nearly state-of-the-art skill in just a few *hours* of self-training

A few chess variants

- **Chess960**
  - invented by Fischer – start with pieces in a random(ish) arrangement, lowers the value of memorizing openings

- **Bughouse**
  - 2 teams of 2, 2 boards, captured pieces are passed to the teammate's board side

- **Chessboxing**
  - as the name implies, chess and boxing (alternating rounds, not simultaneous)

- **Quantum chess**
  - uncertainty builds up about the results of moves until "collapsed"
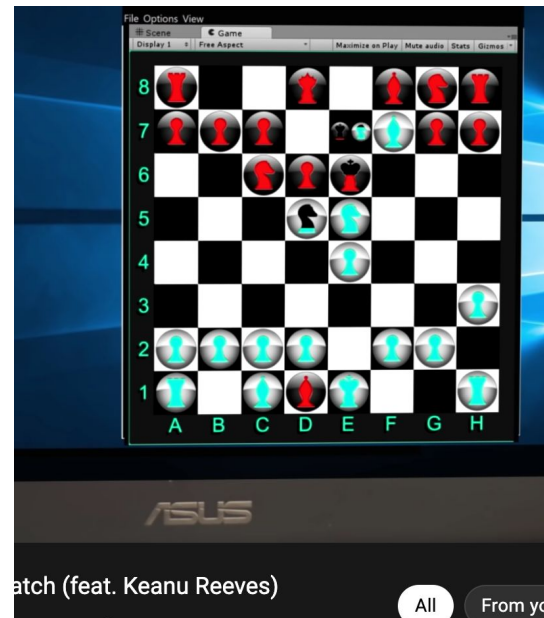
A beautiful puzzle (more on Friday)

1. Don't Win

In this beautiful construction by Karl Fabel, you are trying *not* to win! Can you find the one legal move for White that does *not* mate Black? (Note that you can't just move your own king into check. Or resign. Or flip the table. And it doesn't involve any obscure rules.)

White to play and *avoid giving mate*.