Computação Paralela / Computação Avançada

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What Is Machine Learning ?

Simple Example: the NIM Game

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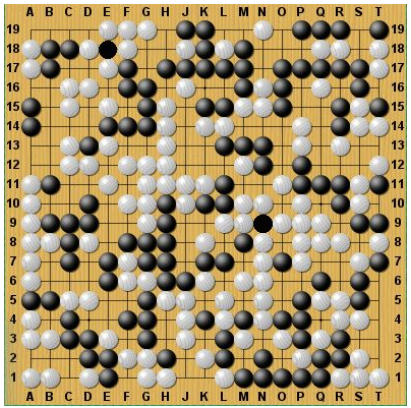
Examples of Popular Historical Milestones in Machine Learning

(recent and not so recent)

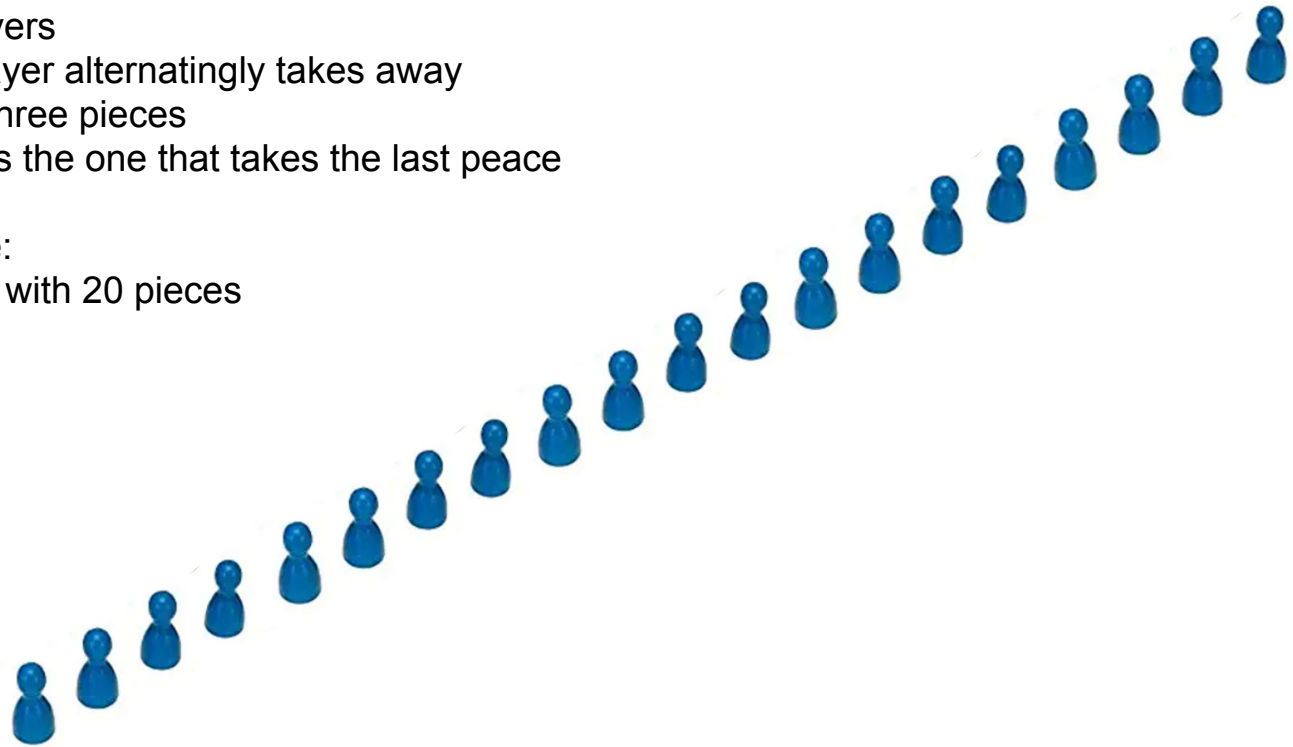


- **1997: Deep Blue versus Garry Kasparov**
  IBM's Deep Blue beats Chess World Champion
  [Wikipedia: Deep Blue versus Garry Kasparov]
  7 different pieces, 64 fields: $15^{64} < 1.8 \times 10^{75}$ combinations
  Na verdade, são muito menos!
- **2016: AlphaGo versus Lee Sedo 2016**
  Google's AlphaGo beats the GO World Champion
  [Scientific American: How the Computer Beat the Go Master]
  [The Guardian: AlphaGo seals 4-1 victory over Go grandmaster Lee Sedol]
  [Nature: Google AI algorithm masters ancient game of Go]
  2 different pieces, 19x19 fields: $3^{361} = 1.7 \times 10^{172}$ combinations

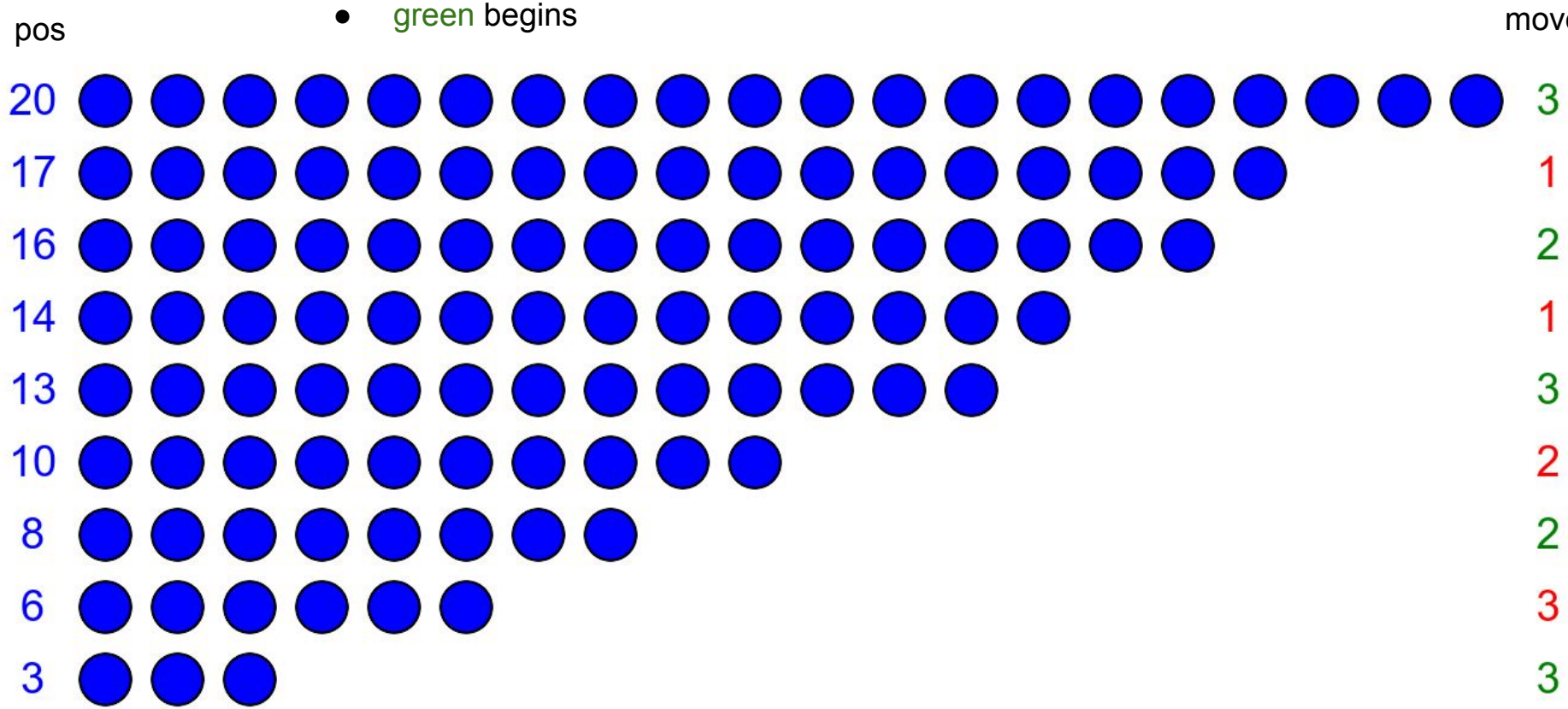
The NIM Game
Very Basic One-Line Version

- Two players
- Each player alternatingly takes away
  1, 2, or three pieces
- Winner is the one that takes the last peace

- Example:
  We start with 20 pieces

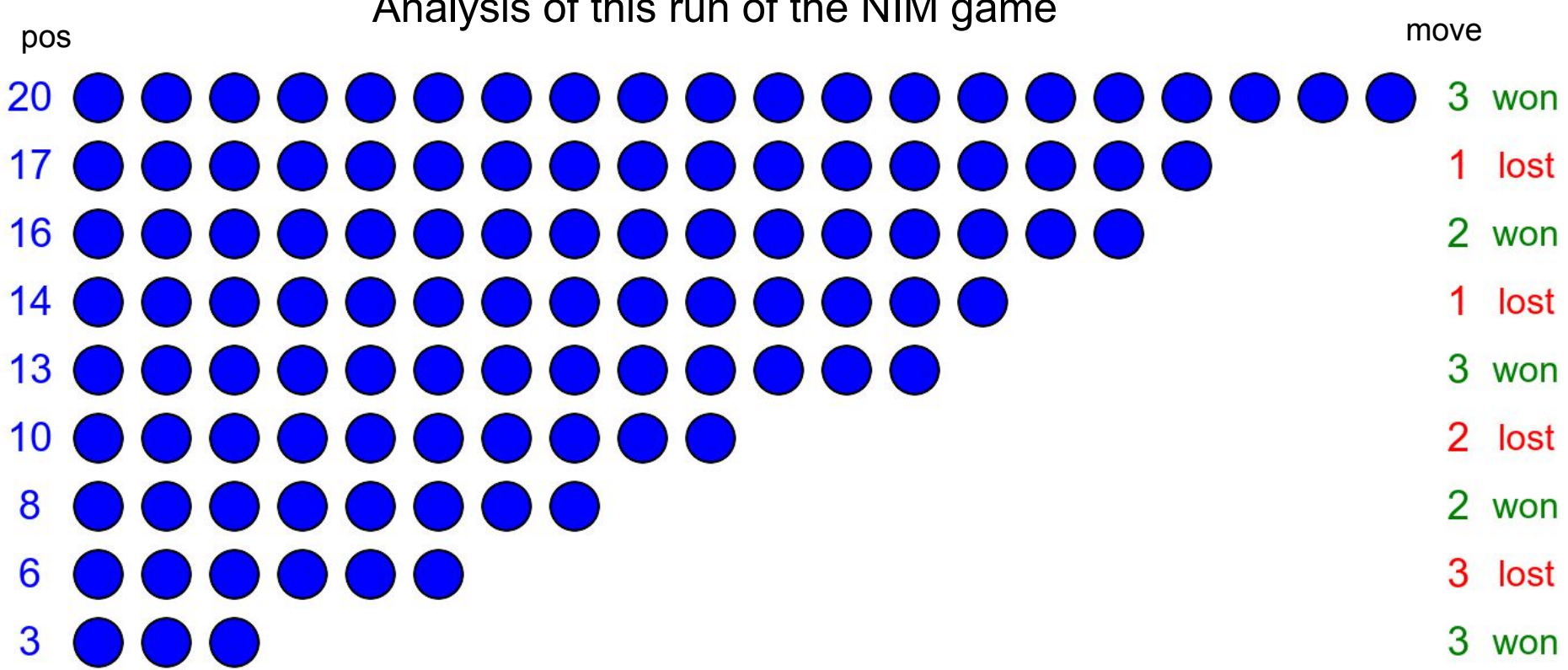


- Two players: green and red
- 20 pieces at start
- green begins



- green wins

Analysis of this run of the NIM game



How can we make the computer learn from this?

- At start, all moves have the same value. Let’s choose 0.
- We run the game. Every player makes a random move.
- After each run, we analyze the moves both players made.
- The moves of the winning player gain 1 value.
- The moves of the losing player lose 1 value.
- We repeat this procedure many times.

Possible improvement:

- Instead of a random move, we already use the values choosing the best move
- Only randomize if the best move is not unique
- … **or is it a worsioning !?**

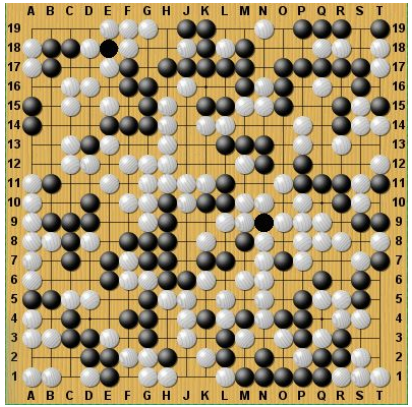
What are the parameters in our game?

- Game position n. For example, n=20 at start, so $1 \leq n \leq 20$
- Move m. m is 1, 2 or 3
- We keep a value for each possible combination value[n, m]
- For each run:
  - we keep track of both players' moves, in two separate lists of moves
  - After the run:
    - all moves of the winning player gain a point: value[n, m] += 1
    - all moves of the losing player loose a point: value[n, m] -= 1
- Analyse result
- Repeat until you see a structure

That's basically what Google did for the GO game.

Just this game is "slightly" more complex…

AlphaGo versus Lee Sedo 2016:



- A lot of possible states of the game
- A lot of possible moves for each move
  ⇨ BIG DATA and BIG Computing Clusters

- The GO game has **far too many possible states** as if you could perform a systematic logical study, even with storage available today
- So they just had the computer play against itself a huge number of times and analyse the winning positions that turned up in the random setups
- **In 2016 the system managed to beat the GO World Champion Lee Sedo**

- One interesting outcome was that the computer made moves into situations that nor the world champion nor any other GO player had ever considered.

- **No artificial intelligence here - just machine learning:**
  Very big data + simulation + statistical analysis
  But it is an independent computer-only approach to find the best solution, without any human input about how to play

- **20 years earlier (1997): Deep Blue versus Garry Kasparov**
  IBM's Deep Blue beats Chess World Champion Garry Kasparov

  This was still a more "classical" approach.
  A very fast hardware and a huge memory that had millions of standard situations stored with their best moves, implemented with the help of chess experts

The Classical NIM Game

- Two players
- Each player alternatingly takes away as many pieces as they like from one single row, at least one piece
- Winner is the one that takes the last piece

- Example:
  4 rows with 1, 3, 5, and 7 pieces

- Wikipedia: The Nim Game

- Is there a winning strategy?
- We can try to find out by adapting our machine learning algorithm from the one-row example using a more complex data model
- The trick is to create a list of all possible game states with their possible next moves