What is AlphaGo?

- AlphaGo is a computer program created by Google Deepmind to play the ancient oriental game of Go

- AlphaGo was the first program to defeat a professional human Go player, Fan Hui, in October 2015; this was written up in the prestigious scientific journal *Nature*

- AlphaGo defeated the many-time world champion human player, Lee Sedol, 4-1 in a match in Seoul, South Korea, in March 2016

- This triumph for Artificial Intelligence was unexpected, coming at least a decade earlier than anticipated. Many thought it would never happen.


oogle DeepMind
Challenge Match
8 - 15 March 2016


KBA
Google DeepMind
Challenge Match
8 - 15 March 2016
AlphaGo
ALPHAGO
01:58:31
LEE SEDOL
01:59:41
AlphaGo
Lee Sedol
Google DeepMind
Challenge Match
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The University of Alberta connection

the lead researchers were UofA alumni

Mastering the game of Go with deep neural networks and tree search

David Silver[1]*, Aja Huang[1]*, Chris J. Maddison[1], Arthur Guez[1], Laurent Sifre[1], George van den Driessche[1], Julian Schrittwieser[1], Ioannis Antonoglou[1], Veda Panneershelvam[1], Marc Lanctot[1], Sander Dieleman[1], Dominik Grewe[1], John Nham[2], Nal Kalchbrenner[1], Ilya Sutskever[2], Timothy Lillicrap[1], Madeleine Leach[1], Koray Kavukcuoglu[1], Thore Graepel[1] & Demis Hassabis[1]

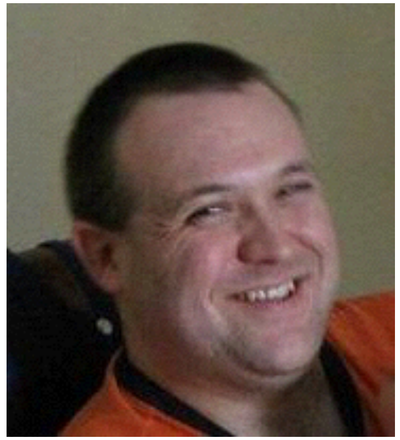
David Silver, PhD CS, 2004-10, supervised by Martin Mueller and me

Aja Huang, PDF CS, 2011-12, supervised by Martin Mueller and Ryan Hayward

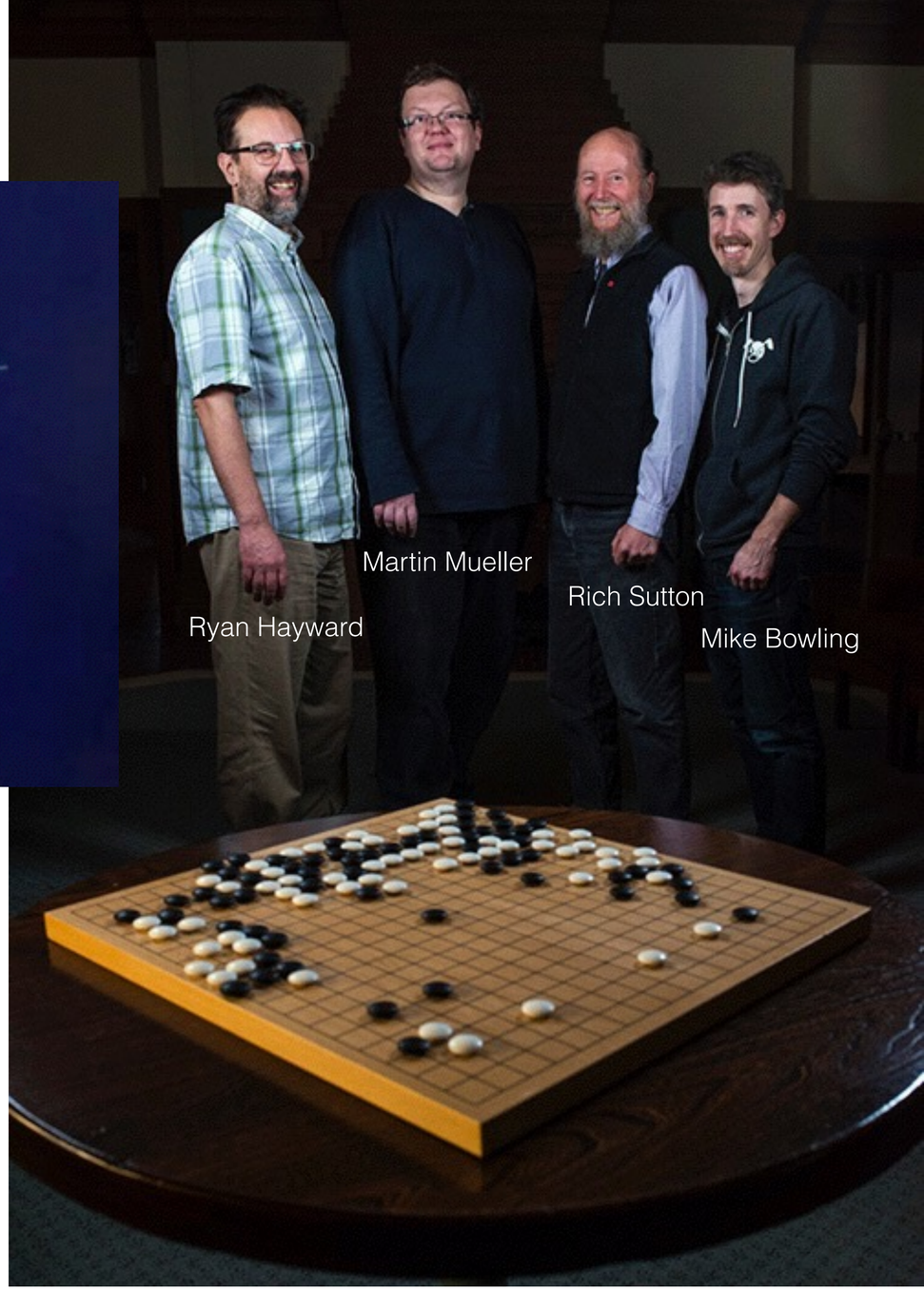
Marc Lanctot, PhD CS, 2013, supervised by Mike Bowling

David Silver

Aja Huang



Marc Lanctot

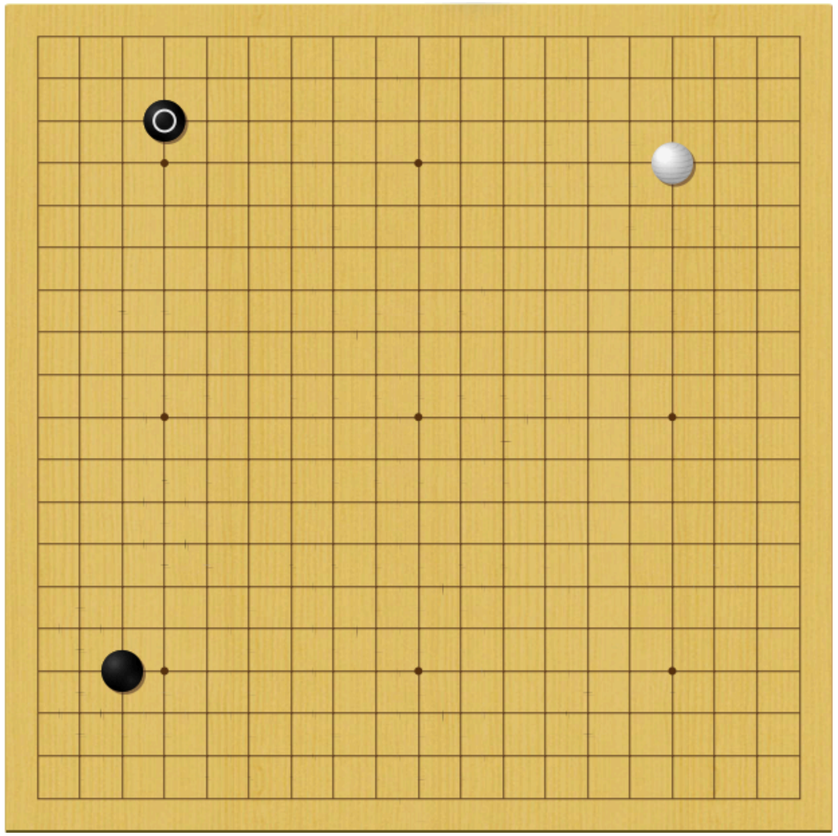


Go

- The *oldest* game still played in its original form
- The *second most played* game in the world (after Chinese chess)
- Japan, China, and South Korea all have cable TV channels *devoted entirely to Go*
- Top Go players can earn a *million dollars* a year

How to play Go

- The board has 19 x 19 ‘points’, the intersections of the lines
- On each move, a player places one ‘stone’ on a point
- If a group of stones is completely surrounded, then it is lost and removed from the board
- The player that surrounds the most territory wins



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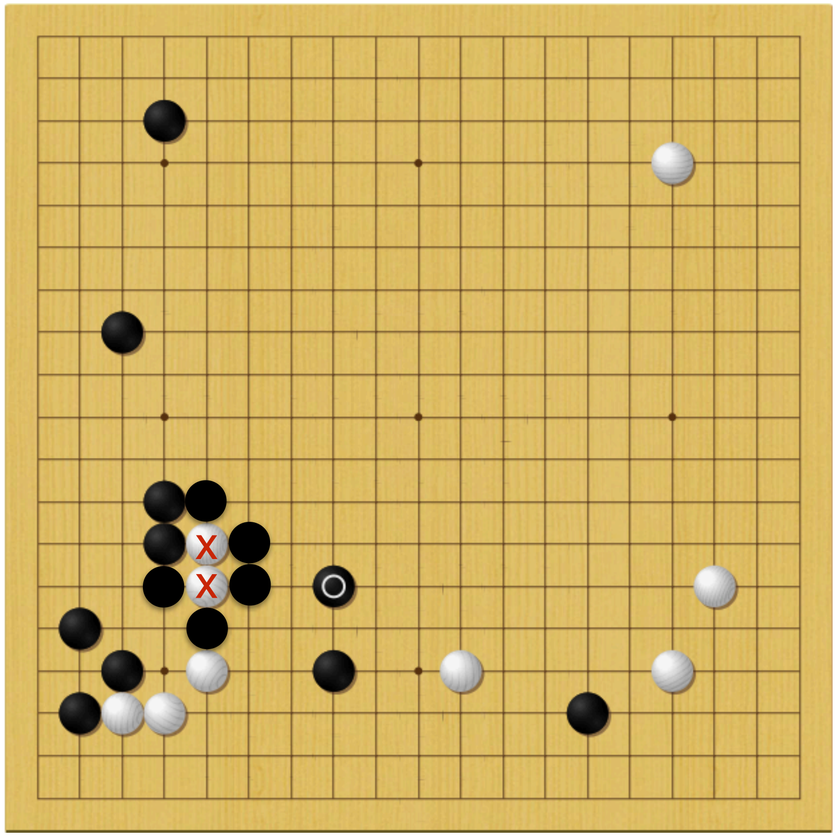

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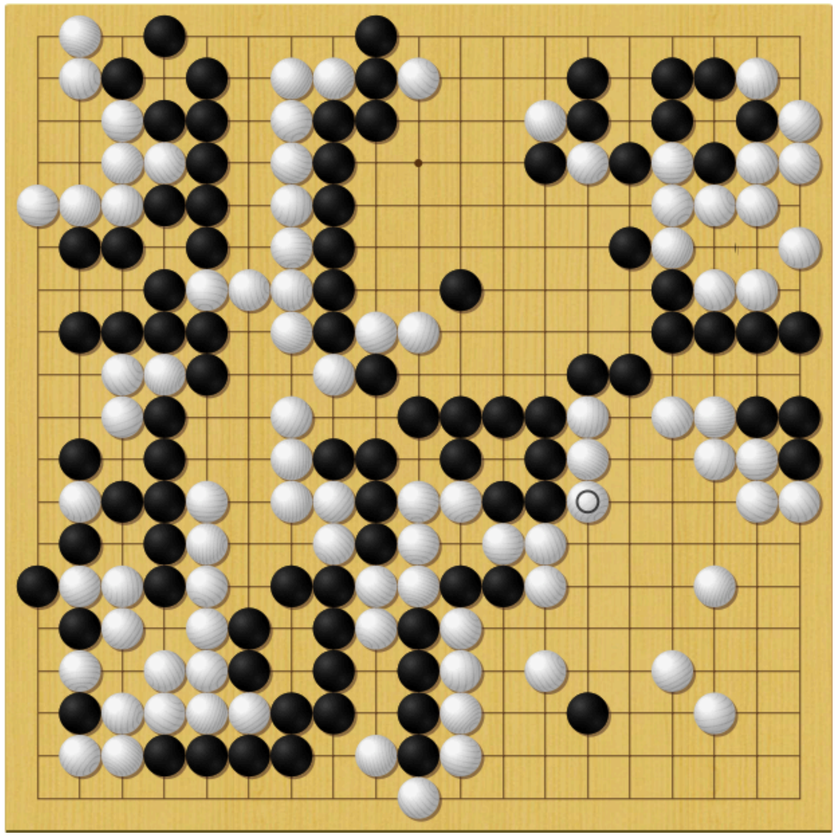

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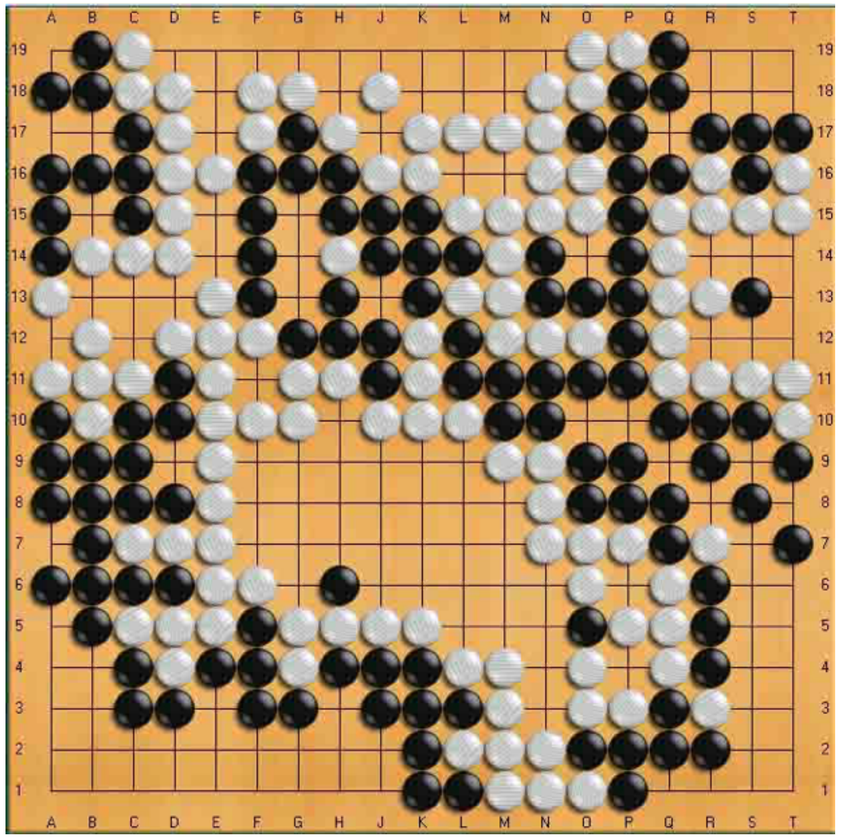


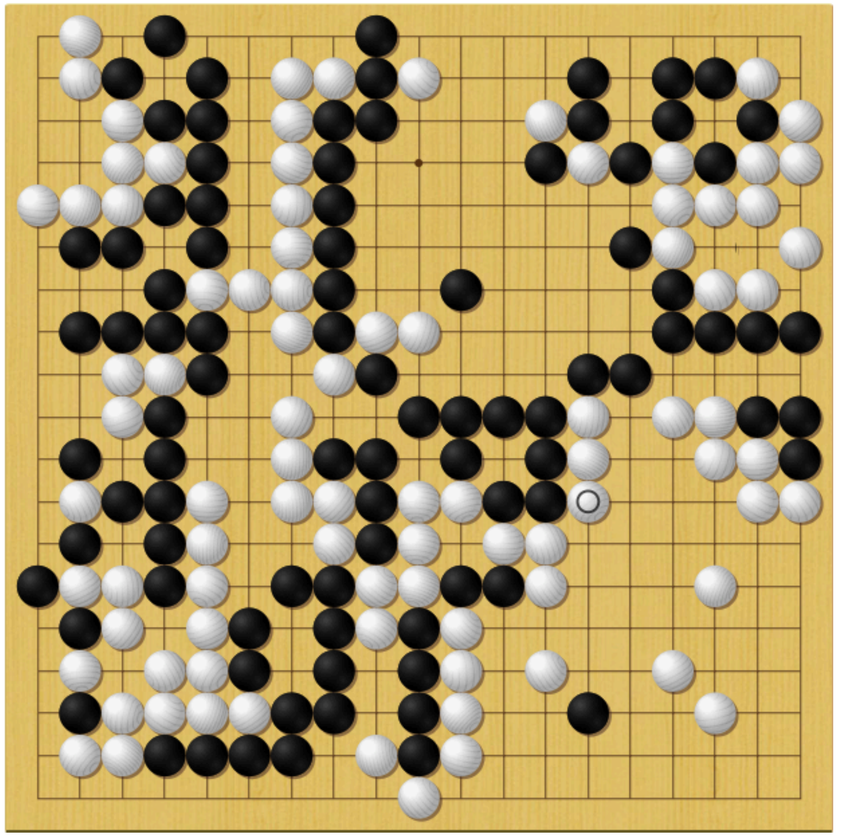
Compare with Chess…

Deep Blue, a computer built by IBM, defeated the human world chess champion, Gary Kasparov, in 1997

Murray Campbell, U Alberta undergrad

Go is much more complex than chess

- A chess game lasts about 50 moves, a Go game about 150
- Chess has ≈30 legal moves at each step, whereas Go has ≈300
- The latter, called the *branching factor*, is key
- Overall complexity is roughly the branching factor carried to the power of the number of moves
  - Chess: 30^{50} Go: 300^{150}
- Go is more complex by a factor of a 1 followed by 250 zeros
- The methods used on chess did not work on Go, success seemed decades away



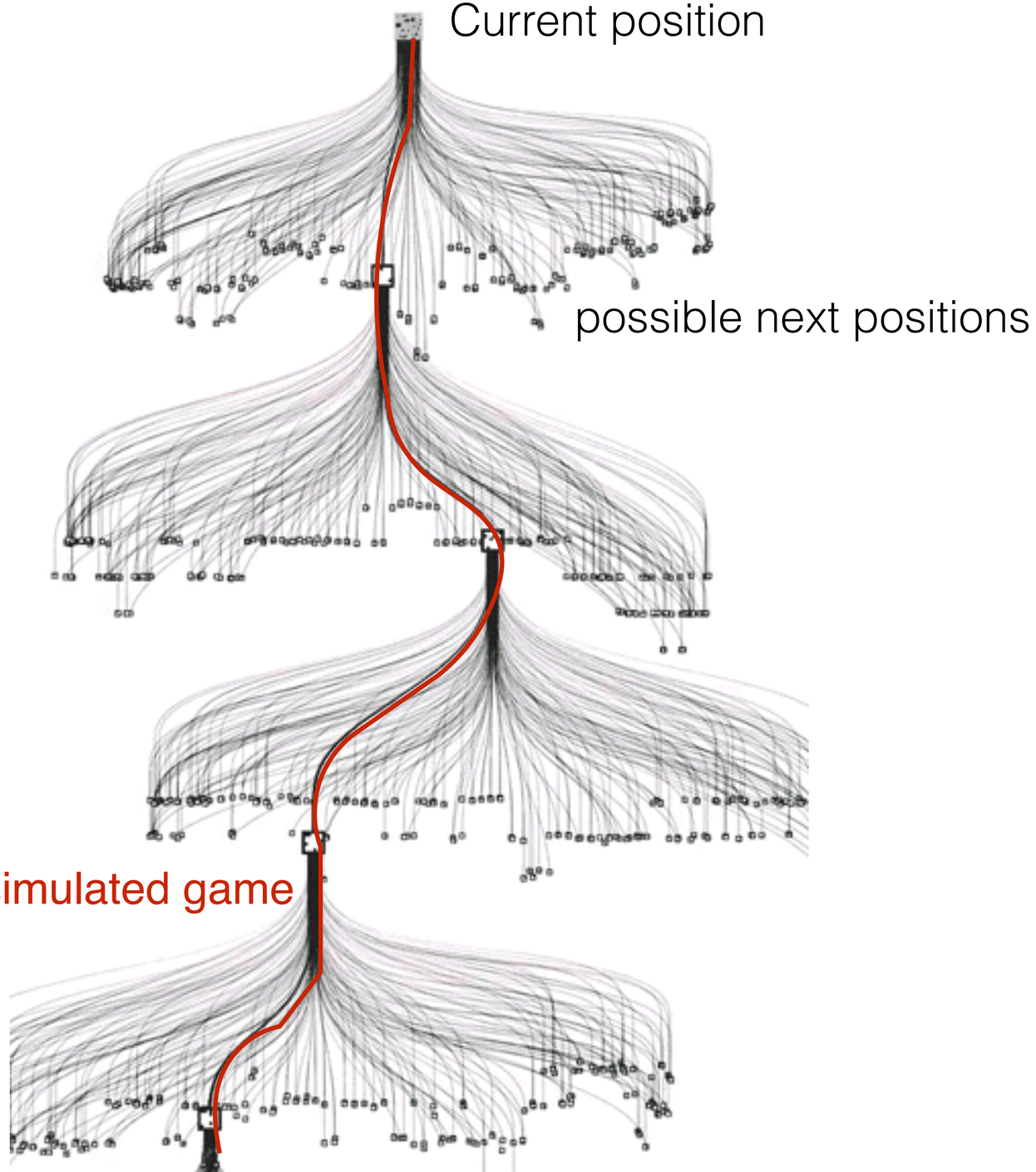
Innovations in AlphaGo (why it worked)

- A new *sampling-based* search method — Monte Carlo Tree Search (MCTS)

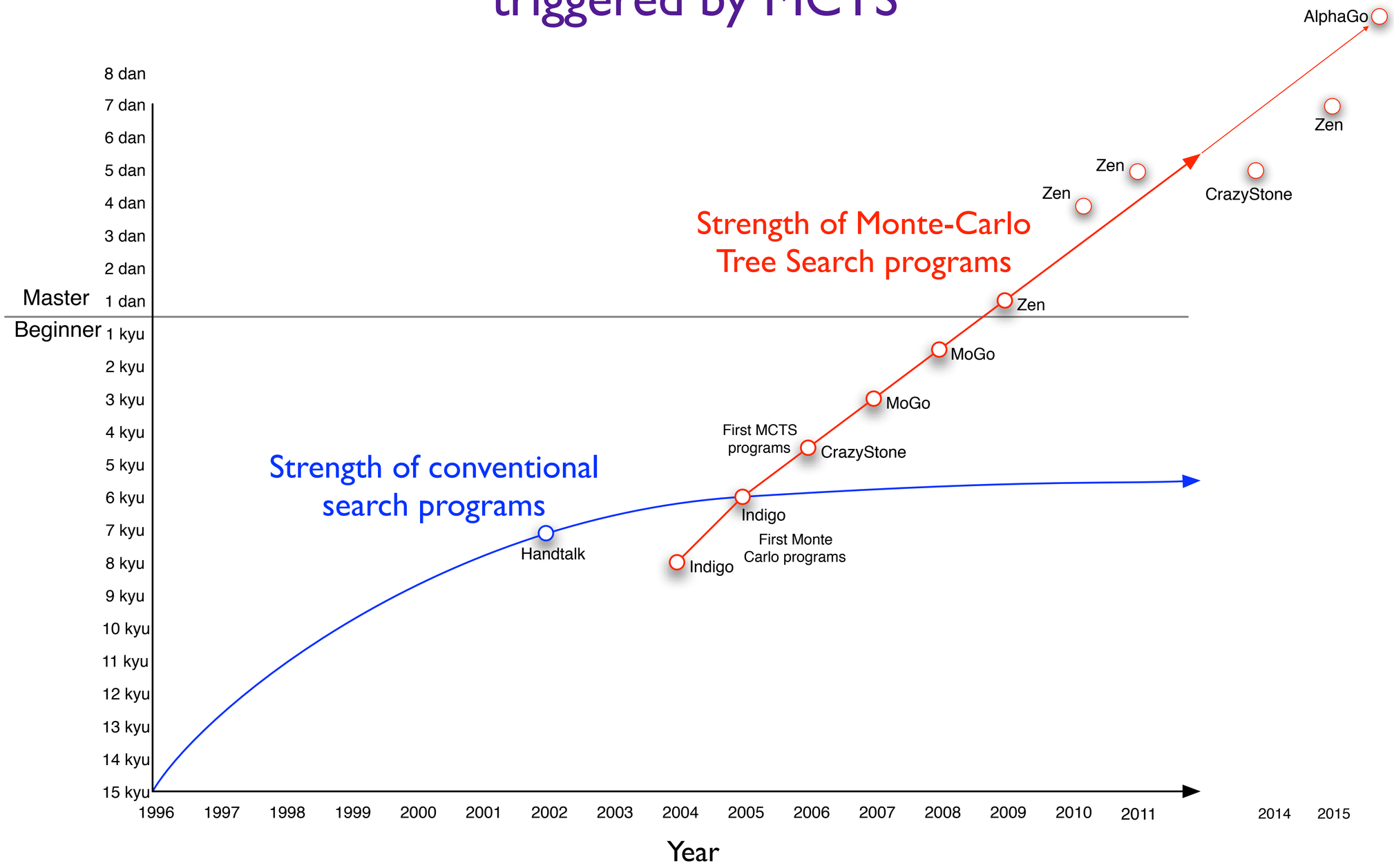
  Kocsis and Szepesvari, 2006

- A learned evaluation function using artificial neural networks (deep learning)
- Reinforcement learning of a default policy from self play
- Lot's of system engineering
- Moore's law (the continued exponential increased in computer power)

Sampling-based look-ahead search (MCTS)



Exponential improvement in the strength of the best computer Go programs triggered by MCTS



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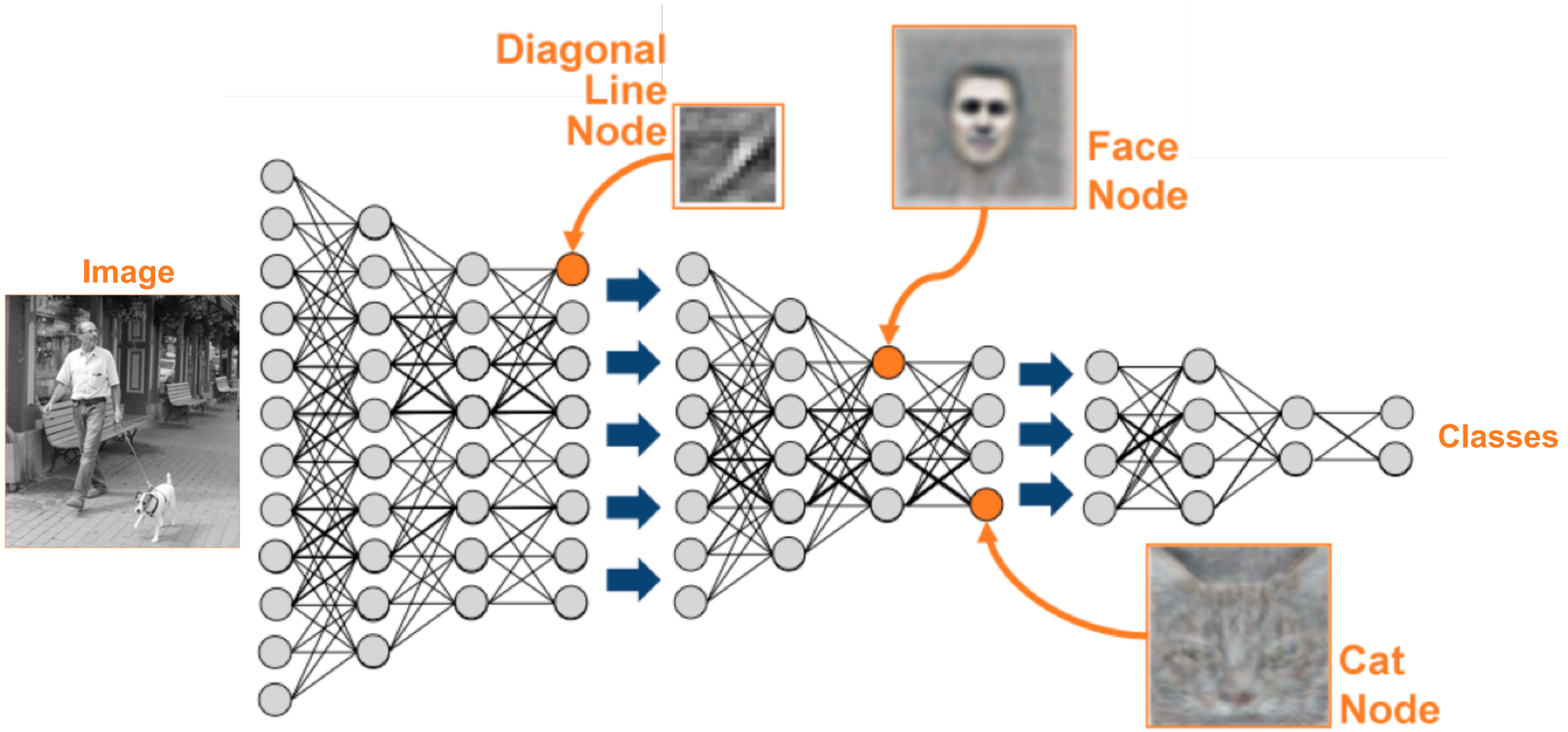
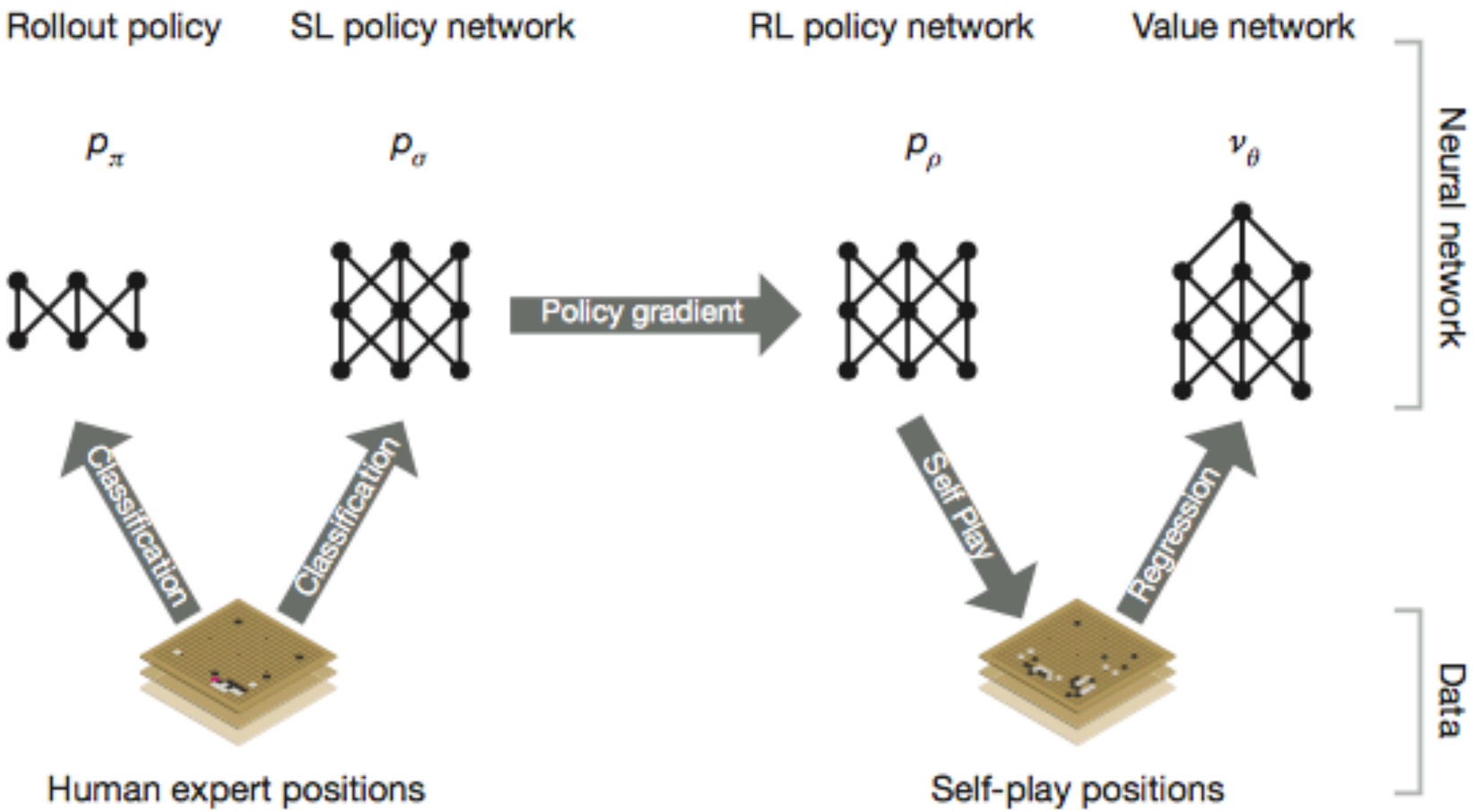
Deep learning

≡ multi-layer neural networks with many layers



- Each line has a learned connection weight
- Each node combines its weighted inputs, then applies a nonlinear transformation
- For each image, the network produces class labels as output, and true class labels are provided by people (supervised learning)
- Then each weight is incremented so as to reduce the squared error (stochastic gradient descent, backpropagation)

AlphaGo pipeline produces an approximate state-value function



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- *Reinforcement learning* of a default policy from self play

  Sutton, McCallester, Singh, Mansour, 2003

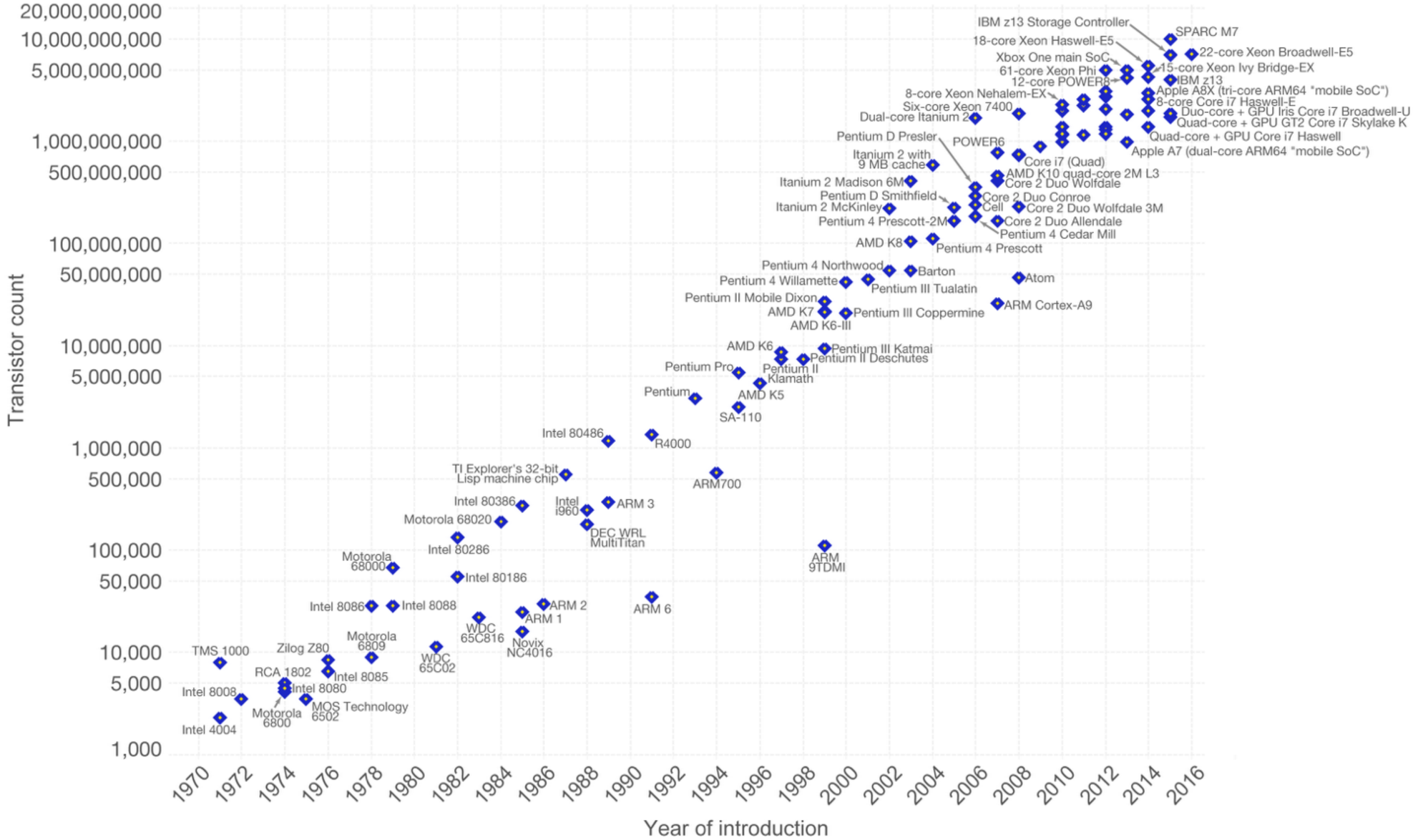
- Lot's of system engineering

- Moore's law (the continued exponential increased in computer power)

Moore's Law – The number of transistors on integrated circuit chips (1971-2016)

Our World in Data

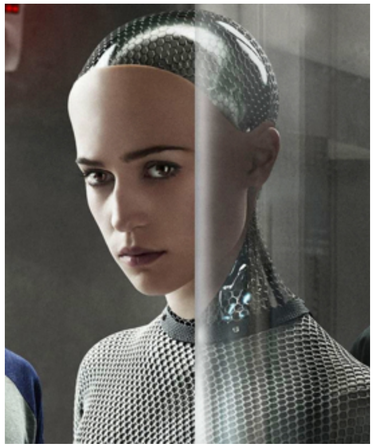
Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are strongly linked to Moore's law.



Data source: Wikipedia (https://en.wikipedia.org/wiki/Transistor_count)

The data visualization is available at OurWorldinData.org. There you find more visualizations and research on this topic.

AlphaGo is a taste of things to come



- AlphaGo is specialized, narrow artificial intelligence
- But it hints at something more foundational that is coming
  - Machine performance has greatly improved in recent years: *Jeopardy!*, Poker, speech and object recognition, autonomous driving, language translation…
- There will come a time when we *understand the principles of intelligence*
- It will be a great, good thing, but it will challenge and change us on many levels

Nick Bostrum on what kind of AI will be successfull

“Artificial Intelligence: Are we engineering our own obsolescence?”

https://www.youtube.com/watch?v=u0R6pV_aeLc