# Lecture 1B - What is AI?

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Readings:Poole & Mackworth 1.1



## Study of AI

Understand principles and build devices that embody them

Can machines fly?

Can machines think?

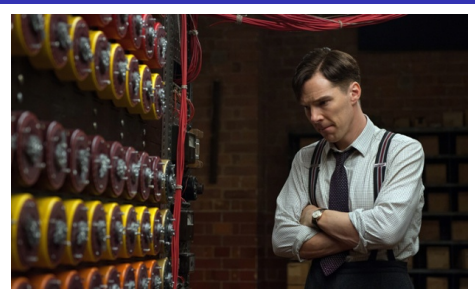


## Goals of Artificial Intelligence Research

- Scientific: Understand the Principles that make intelligent behaviour possible in natural or artificial systems
  - **analysis** of natural and artificial agents
  - **testing hypotheses** about the construction of intelligent agents
  - **building and experimenting with** intelligent agents
- Engineering: Design and build useful intelligent artifacts



## History of AI: the Turing Test

Alan Turing: 1912-1954 was primariliy known for codebreaking in WW11 (`https://www.imdb.com/title/tt2084970/`)
Also asked 'can machines think?', proposed the imitation game:

> The interrogator is connected to one person and one machine via a terminal, therefore can't see her counterparts. Her task is to find out which of the two candidates is the machine, and which is the human only by asking them questions. If the machine can "fool" the interrogator, it is intelligent.

## Conversations

**ELIZA - (1966 Joseph Weizembaum, Lisp)**

ME: Hi
ELIZA: How do you do? What brings you to see me?
ME: I'm thinking of taking a course in artificial intelligence.
ELIZA: Why do you say that?
ME: I'm worried about it
ELIZA: Are you worried often?
ME: when I take AI courses
ELIZA: What happened when you take ai courses?
ME: I usually spend long nights doing assignments
ELIZA: Earlier you said you felt worried?
ME: about AI courses
ELIZA: Maybe your plans have something to do with this.
ME: no
ELIZA: Why not?
ME: because I think you are a computer
ELIZA: Is it because you think I am a computer that you came to me?



## Loebner Prize - Turing test competition

- fool all judges: $1m prize
- no one has ever won
- example interaction:

CONFEDERATE: Hello, my name is Sam and I am the human
JUDGE: Hi Sam, tell me which is larger, a TV screen or Belgium.
CONFEDERATE: Belgium is a little bit larger.
JUDGE: Wljso lwjejdo wleje elwjeo wjeol, isn't it?
CONFEDERATE: Is that Polish?
JUDGE: Which is further away from this apartment, Queens or the Queen of England?
CONFEDERATE: If the Queen is visiting Manhattan, she is closer.



## Loebner Prize

- Jabberwacky (Rollo Carpenter)
- just spits back nonsense,
- was very competitive for many years

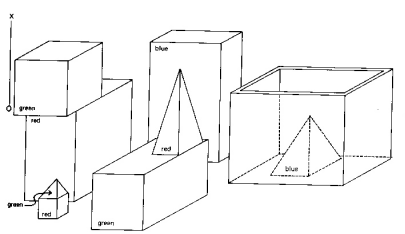
JABBERWACKY: Hello, my name is George and I am the human.
JUDGE: If lsjkel lwehlx wouldn't you say?
JABBERWACKY: No, he's still good.
...
JUDGE: Which is further away from us, Queens or Inner Mongolia?
JABBERWACKY: HA! HA! That was stupid. Tell me a GOOD joke this time.
...
JUDGE: Which is larger, your brain or Belgium?
JABBERWACKY: Oh the one on the far left without a doubt.



## Blocks World - SHRDLU - Winograd 1968

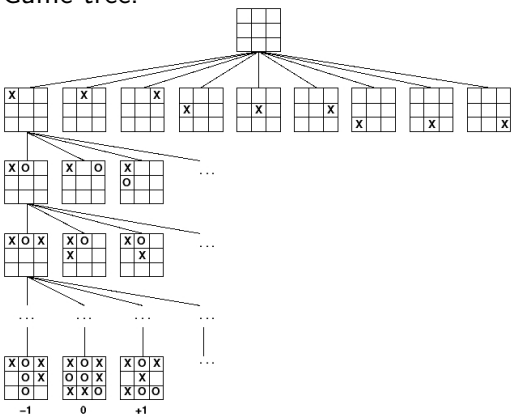
- first autonomous physical interaction
- blocks world only

Pick up a big red block
OK
grasp the pyramid
I DON'T UNDERSTAND WHICH PYRAMID YOU MEAN
What does the box contain?
THE BLUE PYRAMID AND THE BLUE BLOCK.
What is the pyramid supported by?
THE BOX.
How many blocks are not in the box?
FOUR OF THEM.



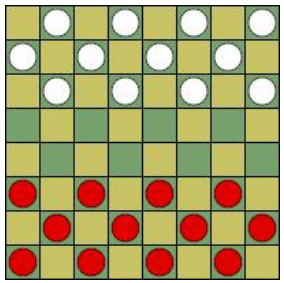
## Game Playing

Two person, Zero-Sum games (competitive)
Game tree:






## Checkers

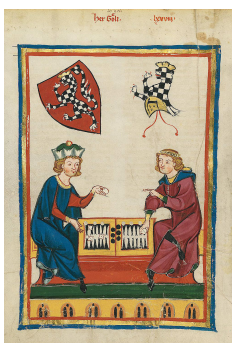


- 500 billion billion nodes ($5 \times 10^{20}$)
- Samuel 1950
- Jonathan Schaeffer, U. of Alberta (1992)
- `https://webdocs.cs.ualberta.ca/~chinook/play/`
- Heuristic search
- "solved" checkers - no search program could do any better
- World champion human-machine player



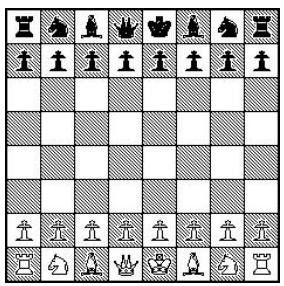
## TD-Gammon

- Gerald Tesauro 1992
- IBM's Thomas J. Watson Research Center
- Neural Network
- Reinforcement Learning
- Just below human play





## Chess



- game tree has more than $10^{100}$ nodes
- IBM - Deep Blue
- Heuristic Search - search depth: 7-8
- Deep Blue - Kasparov, 1996, Game 1
- Kasparov won 3-2-1

- Campbell, Hoane, Hsu, *Deep Blue* AI 2002 `https://doi.org/10.1016/S0004-3702(01)00129-1`
- Currently: Stockfish 10 `https://stockfishchess.org/` - search depth of about 12
- AlphaZero: Silver *et al.* 2019 `https://doi.org/10.1126/science.aar6404` beat Stockfish 10 155-6 (!)

## Go

- game tree has more than $10^{360}$ nodes
- Google Deep Mind : AlphaGo
- March 2016: AlphaGo beats Lee Sedol 4/5 games
- May 2017: AlphaGo beats Ke Jie 3/3 games
- `https://doi.org/10.1038/nature16961`




## Atari 2600 Games

- Almost no domain knowledge
- Deep Reinforcement learning from pixels
- Convolutional Neural Networks
- better than human on 3/7 games
- arxiv.org/pdf/1312.5602v1.pdf


movie: `https://www.youtube.com/watch?v=V1eYniJ0Rnk`



## StarCraft

- multi-agent problem
- imperfect information (partially observed map)
- large action space ($10^8$ possibilities)
- large state space
- delayed credit assignment
- Google Deep Mind : `https://arxiv.org/pdf/1708.04782.pdf`



## StarCraft - Solved?

Article | Published: 30 October 2019

### Grandmaster level in StarCraft II using multi-agent reinforcement learning

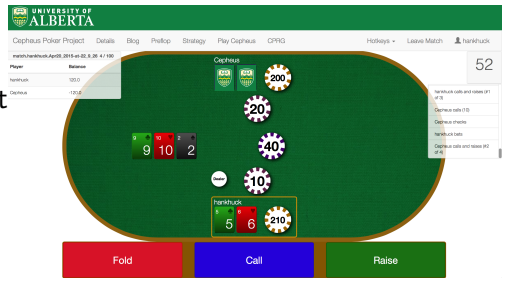
Oriol Vinyals ✉, Igor Babuschkin, Wojciech M. Czarnecki, Michaël Mathieu, Andrew Dudzik, Junyoung Chung, David H. Choi, Richard Powell, Timo Ewalds, Petko Georgiev, Junhyuk Oh, Dan Horgan, Manuel Kroiss, Ivo Danihelka, Aja Huang, Laurent Sifre, Trevor Cai, John P. Agapiou, Max Jaderberg, Alexander S. Vezhnevets, Rémi Leblond, Tobias Pohlen, Valentin Dalibard, David Budden, Yury Sulsky, James Molloy, Tom L. Paine, Caglar Gulcehre, Ziyu Wang, Tobias Pfaff, Yuhuai Wu, Roman Ring, Dani Yogatama, Dario Wünsch, Katrina McKinney, Oliver Smith, Tom Schaul, Timothy Lillicrap, Koray Kavukcuoglu, Demis Hassabis, Chris Apps & David Silver ✉ - Show fewer authors

*Nature* **575**, 350–354(2019) | Cite this article

`https://doi.org/10.1038/s41586-019-1724-z`

## Poker

- Michael Bowling *et al.*
- imperfect information
- Must model opponent
- Long-term payoff
- **Cepheus**
- CFR+: 4800 cores, 68 days: 900 core-years



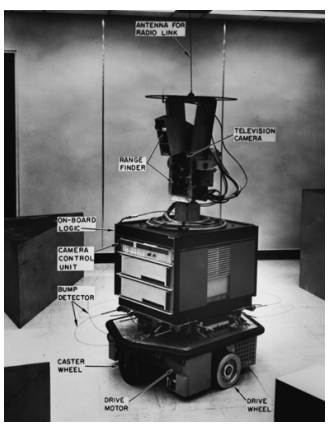

*Heads-up limit hold'em poker is solved* Michael Bowling, Neil Burch, Michael Johanson, and Oskari Tammelin Science 9 January 2015: 347 (6218), 145-149. `https://dx.doi.org/10.1126/science.1259433`



## Video Game AI




## Robotics



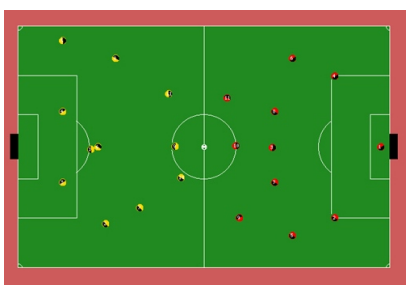

*Shakey*
SRI
1970

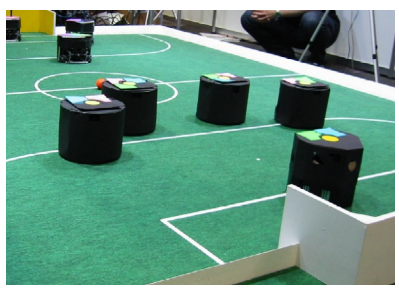
*José*
UBC
2000

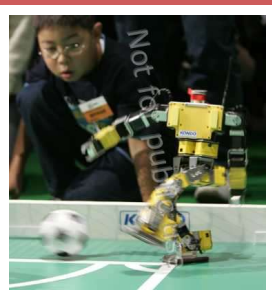
*HRP-4C*
AIST - Hiroshi Ishiguro
2010



## Robotics







## Robotics

- Robocup 2017:
- `https://youtu.be/xkoXeF9oVH4`



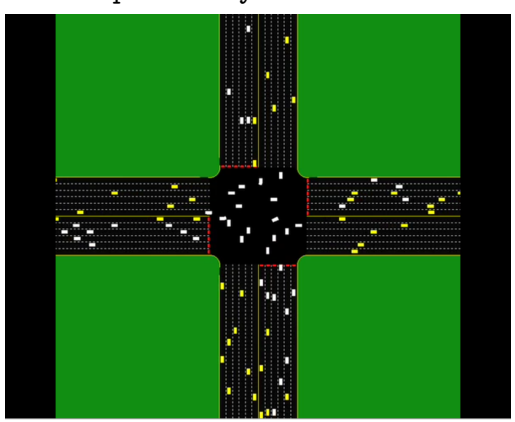
## Autonomous Cars

- "Stanley" won the 2005 Darpa Grand Challenge
- Stanford/Sebastian Thrun




## Autonomous Cars: 10 years?

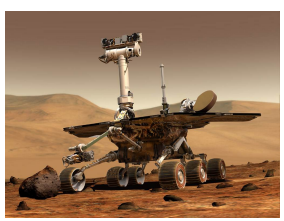
- Peter Stone (UT Austin)
- `http://www.youtube.com/watch?v=4pbAI40dK0A`





## More examples of AI in action

- space exploration
- disaster recovery
- web search
- advertising
- economy - predictions
- knowledge management, engineering
- circuit design, model checking, provability of systems
- air traffic control
- online selling and auctions
- social networks, computational social science and related disciplines
- ...



## Are Self-Driving Cars (or AlphaGo/Deep Blue/etc...) Intelligent?

*The synthesis and analysis of computational agents that act intelligently.*

An agent acts *intelligently* when

- what it does is appropriate for its circumstances and its goals, taking into account the short-term and long-term consequences of its actions
- it is flexible to changing environments and changing goals
- it learns from experience
- it makes appropriate choices given its perceptual and computational limitations



## Autonomous Cars: Flexible enough?

*"They have to learn to be aggressive in the right amount, and the right amount depends on the culture."*

– Donald Norman, Design Lab, UCSD

from: New York Times "Google's Driverless Cars Run Into Problem: Cars With Drivers", 02/09/2015.

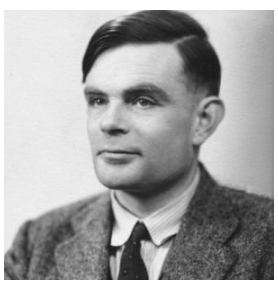


## Autonomous Cars: Flexible enough?


theoatmeal.com/blog/google_self_driving_car

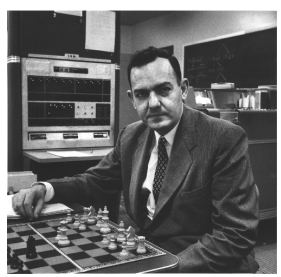


## The Dawn of A.I. (1940s-50s)



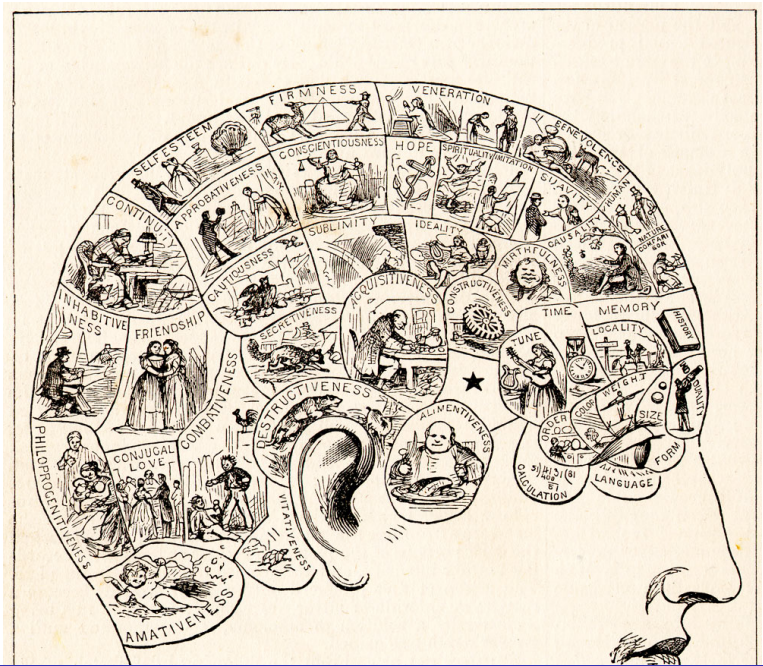
Turing 1950

von Neumann 1944



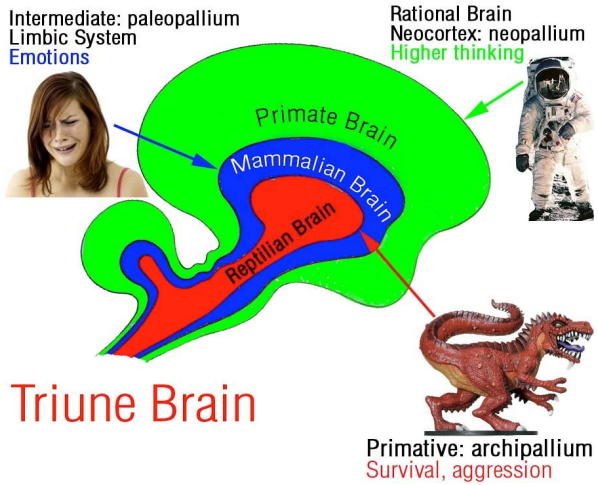
Simon 1967

## Phrenology 1880s






## Limbic/Cortical Systems

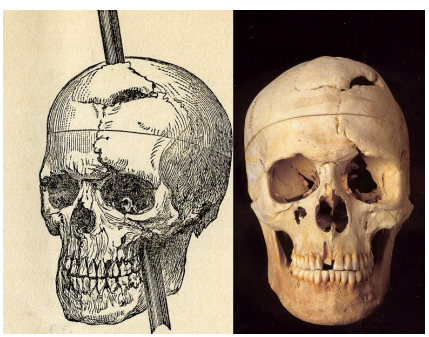



- Paul MacLean's *Triune Brain* 1960s
- limbic ≈ hypothalamus, hippocampus, amygdala
- but these "systems" are really very mixed up in the brain



## Phineas Gage

Antonio Damasio *Descartes' Error* Chapter 1



- Suffered brain damage (frontal lobe)
- Was perfectly good at reasoning and language
- Made disastrous decisions, or could not make decisions
- lacked "somatic markers" - "gut feelings" about decisions



## Emotions and Intelligent Computers

1997: Rosalind Picard in *Affective Computing*

*This book proposes that we give computers the ability to recognize, express and in some case "have" emotions. Is this not absurd?*

Now:

- IEEE Transactions on Affective Computing
- International Conference on Affective Computing and Intelligent Interaction (ACII)
  → `https://acii-conf.net/2022/`
- Increasing awareness that emotions play a significant role in human intelligence
- but, still don't have "emotional machines" - why not?

## Robots have feelings too..

- Darmstadt Dribblers:
- https://www.youtube.com/watch?v=RbAIc-Y6j4o



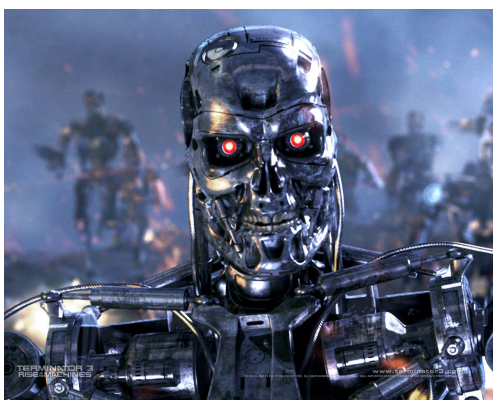
## Emotions: the new AI

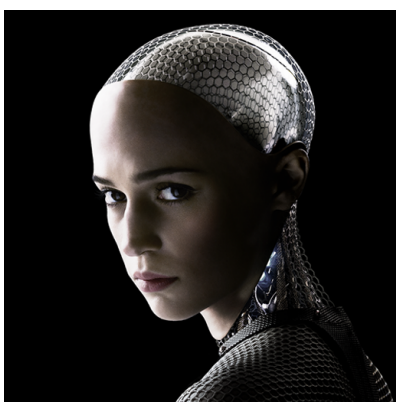
- Artificial Intelligence:
  intelligence = **rationality**
- We now know that **emotions** are *necessary* for intelligence
- Emotions give **"heuristic"** social intelligence
- Encode a **social order** that allows us to work in a society

*With infinite resources, are emotions necessary?*



## The Singularity (von Neumann/Ulam)







## Next:

- Agents (Poole & Mackworth chapter 1.3-1.10,2.1-2.3)
- Search (Poole & Mackworth chapter 3)