Lecture 1B - What is AI?

Jesse Hoey
School of Computer Science
University of Waterloo

January 4, 2018

Readings: Poole & Mackworth 1.1

Study of AI

Mimic life: build artificial versions

Understand principles and build devices that embody them

Can machines fly?

Can machines think?

Animals, Machines and Humans


Figure 2. Schematic representation of human uniqueness and animalistic dehumanisation (adapted from Haslam, 2006).

Figure 3. Schematic representation of human nature and mechanistic dehumanisation (adapted from Haslam, 2006).
Animals, Machines and Humans

- irrationality
- moral sensibility
- amoralithy
- childlikeness
- emotionality
- warmth
- openness
- agency, individuality
- depth
- inertness
- coldness
- rigidity
- passivity
- superficiality
- lack of culture
- coarseness
- maturity
- human nature
- human uniqueness
- animalistic dehumanization
- machinistic dehumanization

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

Alan Turing and the Turing Test

Alan Turing: 1912-1954
Can machines think? - 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: Earlier you said you felt worried?
ME: no
ELIZA: Does it bother you that I ask that?
ME: yes

Loebner Prize

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: Wliso lwjejo wleje elwjeo wjejoul, 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.
JUDGE: If the Queen is visiting Manhattan, won’t she want to abdicate?
CONFEDERATE: I would.
JUDGE: You would rather not be Queen, then, right?
CONFEDERATE: I’d like to be Queen, but England’s damp. How about you?

Jabberwacky (Rollo Carpenter)

JABBERWACKY: Hello, my name is George and I am the human.
JUDGE: If lsjkel Iwehlix 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

- 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.

movie: [https://www.youtube.com/watch?v=QAJz4YKUwqw](https://www.youtube.com/watch?v=QAJz4YKUwqw)

### Game Playing

**Two person, Zero-Sum games (competitive)**

Game tree:

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Checkers

- 500 billion billion nodes ($5 \times 10^{20}$)
- Samuel 1950
- Jonathan Schaeffer, U. of Alberta (1992)
- Heuristic search
- “solved” checkers - no search program could do any better
- World champion man-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
- Currently Houdini 6, Stockfish 8, Komodo 11: search depths of about 20
- Human search depth: 3-4

### 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
- doi: [10.1038/nature16961](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:

Poker

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


Video Game AI
IBM “Watson”
Natural Language understanding
Must be FAST and SPECIFIC
Beat Jeopardy! Champs in 2011
Example questions:
- When Columbus left Spain on August 2nd, 1492, he was aboard this ship
- Columbus scared the locals in Jamaica when he predicted one of these

Robotics

Usable Robotics

Rethink Robotics (Rod Brooks):

Robocup 2017:

Healthcare Robotics: uBOT-5
University of Massachusetts
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

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

– Donald Norman, Design Lab, UCSD

Autonomous Cars: Flexible enough?

Theoatmeal.com/blog/google_self_driving_car

Cognition and Affect (Dualism)

Plato 440BC
- reason: mind, purity, god
- emotions: body, sin, devil

Descartes 1600AD

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

Turing 1950
- von Neumann 1944
- Simon 1967

Artificial Intelligence: Rationalistic

Current State
- Agent Action
- Observation/Alter Action
- Post-Action State
- Next State
- Time

REWARD/UTILITY

Enlightenment, Phenomenology and Social Behaviourism

Mead 1934
- Heidegger 1927
- Smith 1759

Smith:
- "Nay, it is chiefly from this regard to the sentiments of mankind, that we pursue riches and avoid poverty."

Mead:
- "Mind arises through communication [...] in a social process [...], not communication through mind."
Morality: Sentiment or Reason?

Hume 1777 Kant 1785

Hume: Without sentiment, there can be no moral action
→ social-intuitionist rationality (Haidt 2001)
Kant: Categorical Imperative
→ Super-rationality (Hofstadter 1983)

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

Neurophysiologically...
The same idea ...

Who When Affective Cognitive
William James 1890 associative reasoning true reasoning
Heidegger 1927 ready-to-hand present-at-hand
Dreyfus/Ryle 1950 knowing-how knowing-that
Gene Rodenberry 1966 Captain Kirk Spock
George Lucas 1977 Han Solo C3P0
Joseph LeDoux 1998 Low Road High Road
Stanovich/West 2000 System I System II
(Kahneman) 2011
Jonathan Haidt 2001 intuitive reasoning
Paul Thagard 2006 hot thought cold thought

Why do we need a “low road”?

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)
  → acii2017.org
- Increasing awareness that emotions play a significant role in human intelligence
- but, still don’t have “emotional machines” - why not?

Traditional Affective Computing

- Herbert A. Simon *Motivational and emotional controls of cognition*
- Emotions as “interrupts” to cognitive processing
- Coping strategies to “deal with” emotional interrupts
- Increased complexity of interaction → increased “emotionality”
- Increased “emotionality” → increased cognitive explanations and coping strategies
- Increased cognitive burden → increased interrupts
- Increased interrupts → increased complexity of interaction ...

Artificial Intelligence - Cognitive and Emotional

**Traditional AI:**

- environment
  - perception
  - cognition
  - action

**Artificial Intelligence - Cognitive and Emotional**

- environment
  - perception
  - cognition
  - emotion
  - action
Socio-Cultural (Two-System) views

Artificial Intelligence: Individualistic/Rational
Artificial Intelligence: Collective/Phenomenological

suggest
commit
human
computer

Artificial Intelligence: Collective/Phenomenological

suggest
commit
human
computer

Osgood's Semantic Differential


Fundamental Sentiments

asleep
Activity
hyper
strong
Power
weak
bad
good Evaluation

serene
abusive
bossy
polite
Emotions: the new AI

- Artificial Intelligence: intelligence = rationality
- We now know that emotions are necessary for intelligence
- A low road gives “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)

I'm sorry Dad, but Siri made me do it....