Intelligent Control and Cognitive Systems

An Introduction to Artificial Intelligence and Cognition

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Outline

• Last Time:
  • Defined intelligence in terms of behaviour. Talked about sensing for action.

• This time:
  • Why focus on action? What about cognition?
  • Intro to Cognitive Architectures.
Coursework

- Academic writing is part of what you learn here.

- Hypothesis & outcome are introduced in the Introduction, Approach describes experiments. *Titles communicate results.*

- The robot is there so you can learn, and to give you something to do write about.

- The coursework is marked for writing science, and understanding of material.
Resources

• Lots of books in the library (many on LEGO robots!)

• Russel & Norvig is the ultimate AI textbook (for the last decade), though comes from a CMU & Stanford perspective.

• Norvig & Thrun’s Stanford AI lectures are available online.
Quick History of AI

• Early 20c Turing invents CS to solve AI.


• Proposal used the phrase “artificial intelligence”, apparently for the first time.
The Dartmouth Proposal

We propose that a 2 month, 10 man study of artificial intelligence be carried out...

McCarthy & Minsky et al 1956
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McCarthy & Minsky et al 1956
The Summer Vision Project

The summer vision project is an attempt to use our summer workers [11 UGs] effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition"... The primary goal of the project is to construct a system of programs which will divide a vidisector picture into regions such as likely objects, likely background areas and chaos. We shall call this part of its operation FIGURE-GROUND analysis. It will be impossible to do this without considerable analysis of shape and surface properties, so FIGURE-GROUND analysis is really inseparable in practice from the second goal which is REGION DESCRIPTION. The final goal is OBJECT IDENTIFICATION which will actually name objects by matching them with a vocabulary of known objects.

Papert & Minsky (w/ Sussman) MIT 1966
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The CMU Perspective

- Physical Symbol System Hypothesis (Newell & Simon 1963) “A physical symbol system has the necessary and sufficient means for general intelligent action.” Implies:

  - Human thinking is a kind of symbol manipulation (because a symbol system is necessary for intelligence).

  - Machines can be intelligent (because a symbol system is sufficient for intelligence).
Symbols

• Symbols (and sometimes Language) have been thought to define intelligence for a long time.

• Brooks (1991) was a significant challenge to this (more next week).
Mind uploading / whole brain scanning

**Al Heaven**

- If intelligence is just symbol systems, and we’re all Turing compatible...
  - Cartesian dualism should hold.
- We can upload our brains & “live” forever.

*cf. Minsky, Vinge.*
“New AI” (1986)

- AI “wasn’t working” (more on this later in the course).
- Refocus attention on behaviour, robots.
- Produced first robots that could operate at animal-like speeds.

Genghis, MIT 1986
New AI

**Functionalist Assumption:** All we care about is producing intelligent behaviour.

- Physical Symbol System Hypothesis (Newell & Simon 1963); Qualia, Chalmers “hard problem” (1995) **Build thinking first.**


**We’ll build it if we need it.**
Newer New AI

**Functionalist Assumption:** All we care about is producing intelligent behaviour.

- Physical Symbol System Hypothesis (Newell & Simon 1963); Qualia, Chalmers “hard problem” (1995). **Build thinking first.**

- Consciousness as epiphenomena (Churchland 1988, Brooks & Stein 1993).

We’ll build it to see if we need it.

*(Bias alert: Stein was my PhD supervisor)*
Intelligence & Cognition

A European / Brooksian Perspective
Intelligence

• What matters is expressing the right behavior at the right time: action selection.
• Finding the right action requires search.
• Search is intractable.
• Corollary 1: This is why we all act stupid.
• Corollary 2: Culture / concurrency is what makes humans so smart.
Why is it hard to be smart?

Pretend someone handed you a robot brain brick, and it came with 100 things it knew how to do without being told.

For example, eat, sleep, turn right, turn left, step forward, step backward, pick things up, drop them...

Now pick a goal for your robot.

For example, flying to Osaka.
Suppose you can’t be bothered to tell your robot exactly how to get to Osaka, so you have it guess.

If getting to Osaka is a built-in primitive, the robot may have to try 100 different things.

If it requires two steps, the robot may have to try each thing after each thing:

\[ 100^2 = 10,000 \]
If the robot doesn’t know how many steps it takes to go to Osaka, it might get caught in an infinite loop.

For example, it might eat, sleep, work, eat, sleep, work, eat, sleep, work... and never buy a passport.

When computer scientists say “hard” they mean “pretty much intractable.”

Sony SDR-4Xs. Pictures from BBC
Intelligence & Design

- **Combinatorics** is the problem, **search** is the only solution.

- The task of intelligence is to **focus** search.

- Called **bias** (learning) or **constraint** (planning).

- Most `intelligent` behavior has no or little **real-time** search (non-cognitive) (c.f. Brooks IJCAI91).

- For **artificial** intelligence, most focus from **design**.
Intelligence

• What matters is expressing the right behavior at the right time: action selection.

• Conventional AI planning searches for an action sequence, requires set of primitives.

• That set of primitives came from search by the system’s designers.

• ∴ Building AI requires tradeoffs between search by designers & computers.
What About Learning?

• A learning system consists of a representation (state) and an algorithm for changing the values in that representation.

• Learning searches for the right parameter values, requires primitives and parameters.

• No learning algorithm automatically generates AI through invocation.

• Evolution and development are just special kinds of learning.
What About Cognition

Definition:
Cognition is on-line (real-time) search.

Consequence:
Cognition is bad.
Cognition

• Why is cognition / individual search bad?
  • Slow
  • Uncertain

• Unpopular in most species.
  • e.g. Plants
Cognition

• When is cognition useful?

  • **Dynamic environments** – change faster than learning or evolution can adapt.

  • Note this depends on lifehistory.

  • **Baldwin Effect** – fast & noisy search facilitates (speeds up) slower & more reliable learning processes *(Baldwin 1896, Hinton & Nowlan 1987).*
Why History Matters

• A **lineage** is a type of state – a set of data forming a preexisting solution, that then gets improved upon, e.g. through

  • **innovation** – **Generate**
  • **selection** – **Test**
Cognition

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Why Cognitive Systems?

• What artefacts need to be cognitive?
• What artefacts need to adjust in real time?
• (possible answers…) traits:
  • Proactive, interactive, sensing, mapping...
• examples:
  • Smart homes, personal digital assistants / phones, drones.
Summary

• The history of AI through about 1995.
  • More contemporary stuff later in the course
• Introduction to “New AI” and Systems AI.
  • Introduction to discussion of academic / scientific lineages, including mine.