Artificial Intelligence: Introduction

Chapter 1
Outline

We consider here:

- What is AI?
- A brief history
- The state of the art
What is AI?

Consider the following table that can be used to classify definitions of AI:

<table>
<thead>
<tr>
<th>Systems that think like humans</th>
<th>Systems that think rationally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems that act like humans</td>
<td>Systems that act rationally</td>
</tr>
</tbody>
</table>

- On the left side we have a comparison with how humans *behave*.
- On the right side we have a comparison with an *ideal* reasoner.
- The top concerns *reasoning*
- The bottom concerns *behaviour*
Thinking Humanly: The Turing test

Turing (1950) “Computing machinery and intelligence”:

- *Can machines think?* → *Can machines behave intelligently?*
- Operational test for intelligent behavior: the *Imitation Game*
The Turing test

- Anticipated all the major arguments against AI
- Suggested major components of AI: knowledge, reasoning, language understanding, learning
- Problem:
  - TT is not *reproducible* or amenable to *mathematical analysis*
  - Based on *deception*.
    - This is exploited by many entrants for the *Loebner prize*. 
TT Alternative: The Winograd Challenge

Idea:
Ask a series of questions such as:

*Joan thanked Susan for all the help she had given.*

Who gave the help?

a) Joan

b) Susan
TT Alternative: The Winograd Challenge

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Ask a series of questions such as:

*Joan thanked Susan for all the help she had given.*
*Who gave the help?*
  a) Joan
  b) Susan

or:

*John could not put the trumpet in the suitcase because it was too large.*
*What was too large?*
  a) the trumpet
  b) the suitcase
The Winograd Challenge

- A human would have an easy time with these questions
- Any existing program would have a *tough* time with them.
- “Google-proof”

See:
Thinking humanly: Cognitive Science

- 1960s “cognitive revolution”: Information-processing psychology replaced the prevailing view of *behaviorism*
- Required scientific theories of internal activities of the brain
  - What level of abstraction? “Knowledge” or “circuits”?  
  - How to validate? Requires  
    1) predicting and testing behavior of humans (top-down) or  
    2) direct identification from neurological data (bottom-up)
- Both approaches (roughly, *Cognitive Science* and *Cognitive Neuroscience*) are now distinct from AI
- Both share with AI the following characteristic: *The available theories do not explain (or engender) anything resembling human-level general intelligence*
- Hence, all three fields share one principal direction!
Thinking rationally: Laws of Thought

Ask:
How *should* a rational agent think?

- So, *normative* (or *prescriptive*) rather than *descriptive*
- Aristotle first asked: what are correct arguments/thought processes?
- Over the last 100 or so years, formal *logic* has been developed to provide principles of correct reasoning.
- Arguably logic says how an agent *should* think.
Thinking rationally: Laws of Thought

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Problems:
1. Not all intelligent behavior is mediated by logical deliberation
2. There is a big difference between solving a problem in principle and in practice.
Another measure of intelligence is whether the agent does the “right thing”.

- So, *rational behavior* = doing the right thing
Acting rationally

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- So, *rational behavior* = doing the right thing
- *Q:* What is “doing the right thing”? 

The text (and the course) will concentrate on general principles of rational agents and on components for constructing them.
Acting rationally

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- *Q*: What is “doing the right thing”?  
  *A*: That which is expected to maximize goal achievement, given available information
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- So, *rational behavior* = doing the right thing
- *Q:* What is “doing the right thing”?  
  *A:* That which is expected to maximize goal achievement, given available information
- May not involve thinking (e.g., blinking reflex) but thinking should be in the service of rational action
- May not be able to guarantee the best outcome.

The text (and the course) will concentrate on general principles of rational agents and on components for constructing them.
Rational agents

An *agent* is an entity that *perceives* and *acts*
Rational agents

An agent is an entity that perceives and acts

- This course is about designing rational agents
- Abstractly, an agent is a function from percept histories to actions:

  \[ f : \mathcal{P}^* \rightarrow \mathcal{A} \]

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
- Problem: computational limitations make perfect rationality unachievable

So we want to design the best program for given machine resources
AI prehistory (see the text)

Areas that have some bearing on AI:

**Philosophy**  logic, knowledge representation, reasoning, foundations of learning, language, rationality

**Mathematics**  formal representation and proof, algorithms, computation, (un)decidability, (in)tractability, probability

**Psychology**  adaptation, perception and motor control, experimental techniques (psychophysics, etc.)

**Economics**  formal theory of rational decisions

**Linguistics**  knowledge representation, natural language understanding, grammar

**Neuroscience**  physical substrate for mental activity

**Control theory**  homeostatic systems, stability, simple optimal agent designs
Selected history of AI (again, see the text)

1950  Turing’s “Computing Machinery and Intelligence”
1950s  Early AI programs, including Samuel’s checkers program, Newell & Simon’s Logic Theorist,
1956  *Dartmouth meeting*: “Artificial Intelligence” adopted
1965  Robinson’s complete algorithm for logical reasoning
1966–74  AI discovers computational complexity
          Neural network research almost disappears
1969–79  Early development of knowledge-based systems
1980–88  Expert systems industry booms
1985–95  Neural networks return to popularity
1988–  Resurgence of probability; increase in technical depth
1995–  Intelligent agents as a focus
2001–  Availability of massive datasets
2003–  Some seemingly-impressive applications
State of the art (2010-ish)

What can AI do today?

- NASA’s Remote Agent program is an autonomous planner for spacecraft operations
- Game playing
  - There’s Deep Blue. A team at U Alberta has solved checkers and is working on poker. Also Go.
- Drive a vehicle
  - An autonomous vehicles are around the corner.
- Diagnosis
  - Good progress is being made in (limited) medical diagnosis systems
- Logistics and Planning
  - The text mentions successes in the US in military planning.
State of the art (circa 2010) (continued)

● Robotics
  📚 Surgeon’s assistants. As well, there is steady progress in (e.g.) robo cup

● Learning
  📚 E.g. spam filters

● Problem solving
  📚 E.g. crossword solver. General Game Competition. Others?

● Machine translation

● Others?
State of the art (circa 2010) (continued)

What are some more recent AI successes?
State of the art

What about the following?

• Drive safely along a curving mountain road
• Buy a week’s worth of groceries on the web? At Save-On?
• Play a decent game of bridge? Poker?
• Discover and prove a new mathematical theorem
• Design and execute a research program in molecular biology
• Write an intentionally funny story
• Give competent legal advice in a specialized area of law
• Translate spoken English into spoken Swedish in real time
• Converse successfully with another person for an hour
• Perform a complex surgical operation
• Unload a dishwasher and put everything away