# Artificial Intelligence

Chapter 1



## Outline

♢ What is AI?

♢ A brief history

♢ The state of the art



## What is AI?

| | |
|---|---|
| Systems that think like humans | Systems that think rationally |
| Systems that act like humans | Systems that act rationally |

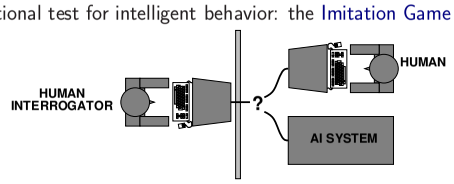


## Acting humanly: The Turing test

Turing (1950) "Computing machinery and intelligence":

♢ "Can machines think?" ⟶ "Can machines behave intelligently?"

♢ Operational test for intelligent behavior: the Imitation Game




♢ Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes

♢ Anticipated all major arguments against AI in following 50 years

♢ Suggested major components of AI: knowledge, reasoning, language understanding, learning

Problem: Turing test is not **reproducible**, **constructive**, or amenable to **mathematical analysis**



## Thinking humanly: Cognitive Science

1960s "cognitive revolution": information-processing psychology replaced prevailing orthodoxy of behaviorism

Requires 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 human subjects (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

Normative (or prescriptive) rather than descriptive

Aristotle: what are correct arguments/thought processes?

Several Greek schools developed various forms of logic:

**notation** and **rules of derivation** for thoughts;

may or may not have proceeded to the idea of mechanization

Direct line through mathematics and philosophy to modern AI

Problems:

1) Not all intelligent behavior is mediated by logical deliberation

2) What is the purpose of thinking? What thoughts **should** I have out of all the thoughts (logical or otherwise) that I **could** have?

## Acting rationally

Rational behavior: doing the right thing

The right thing: that which is expected to maximize goal achievement, given the available information

Doesn't necessarily involve thinking—e.g., blinking reflex—but thinking should be in the service of rational action

Aristotle (Nicomachean Ethics):

**Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good**



## 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

Caveat: **computational limitations make perfect rationality unachievable**

→ design best program for given machine resources



## AI prehistory

| | |
|---|---|
| Philosophy | logic, methods of reasoning |
| | mind as physical system |
| | foundations of learning, language, rationality |
| Mathematics | formal representation and proof |
| | algorithms, computation, (un)decidability, (in)tractability |
| | probability |
| Psychology | adaptation |
| | phenomena of perception and motor control |
| | experimental techniques (psychophysics, etc.) |
| Economics | formal theory of rational decisions |
| Linguistics | knowledge representation |
| | grammar |
| Neuroscience | plastic physical substrate for mental activity |
| Control theory | homeostatic systems, stability |
| | simple optimal agent designs |



## Potted history of AI

| | |
|---|---|
| 1943 | McCulloch & Pitts: Boolean circuit model of brain |
| 1950 | Turing's "Computing Machinery and Intelligence" |
| 1952–69 | Look, Ma, no hands! |
| 1950s | Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine |
| 1956 | Dartmouth meeting: "Artificial Intelligence" adopted |
| 1965 | Robinson's complete algorithm for logical reasoning |
| 1966–74 | AI discovers computational complexity<br>Neural network research almost disappears |
| 1969–79 | Early development of knowledge-based systems |
| 1980–88 | Expert systems industry booms |
| 1988–93 | Expert systems industry busts: "AI Winter" |
| 1985–95 | Neural networks return to popularity |
| 1988– | Resurgence of probability; general increase in technical depth<br>"Nouvelle AI": ALife, GAs, soft computing |
| 1995– | Agents, agents, everywhere . . . |
| 2003– | Human-level AI back on the agenda |



## State of the art

Which of the following can be done at present?

♢ Play a decent game of table tennis



## State of the art

Which of the following can be done at present?

♢ Play a decent game of table tennis
♢ Drive safely along a curving mountain road

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Which of the following can be done at present?

- ♢ Play a decent game of table tennis
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- ♢ Drive safely along Telegraph Avenue



## State of the art

Which of the following can be done at present?

- ♢ Play a decent game of table tennis
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- ♢ Buy a week's worth of groceries on the web



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- ♢ Play a decent game of bridge



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- ♢ Play a decent game of bridge
- ♢ Discover and prove a new mathematical theorem



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- ♢ Design and execute a research program in molecular biology

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- ♢ Write an intentionally funny story



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- ♢ Write an intentionally funny story
- ♢ Give competent legal advice in a specialized area of law



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- ♢ Translate spoken English into spoken Swedish in real time



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- ♢ Converse successfully with another person for an hour



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- ♢ Perform a complex surgical operation



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- ♢ 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 any dishwasher and put everything away

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## Unintentionally funny stories

One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe threatened to hit Irving if he didn't tell him where some honey was. The End.

Henry Squirrel was thirsty. He walked over to the river bank where his good friend Bill Bird was sitting. Henry slipped and fell in the river. Gravity drowned. The End.

Once upon a time there was a dishonest fox and a vain crow. One day the crow was sitting in his tree, holding a piece of cheese in his mouth. He noticed that he was holding the piece of cheese. He became hungry, and swallowed the cheese. The fox walked over to the crow. The End.



## Unintentionally funny stories

Joe Bear was hungry. He asked Irving Bird where some honey was. Irving refused to tell him, so Joe offered to bring him a worm if he'd tell him where some honey was. Irving agreed. But Joe didn't know where any worms were, so he asked Irving, who refused to say. So Joe offered to bring him a worm if he'd tell him where a worm was. Irving agreed. But Joe didn't know where any worms were, so he asked Irving, who refused to say. So Joe offered to bring him a worm if he'd tell him where a worm was . . .