Intelligent Systems

Lecture 1 - Introduction

In which we try to explain why we consider artificial intelligence to be a subject most worthy of study, and in which we try to decide what exactly it is

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What is AI?

A brief history

The state of the art
### What is AI?

<table>
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<th>Systems that think like humans</th>
<th>Systems that think rationally</th>
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<td>Systems that act like humans</td>
<td>Systems that act rationally</td>
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1.1 “The exciting new effort to make computers think ... machines with minds, in the full and literal sense” (Haugeland, 1985)
1.1 “The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning ...” (Bellman, 1978)

1.2 “The study of mental faculties through the use of computational models” (Charniak and McDermott, 1985)
1.2 “The study of the computations that make it possible to perceive, reason, and act” (Winston, 1992)

2.1 “The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990)
2.1 “The study of how to make computers do things at which, at the moment, people are better” (Rich and Knight, 1991)

2.2 “A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes” (Schalkoff, 1990)
2.2 “The branch of computer science that is concerned with the automation of intelligent behavior” (Luger and Stubblefield, 1993)
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 “neurons”?
  – 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 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:

*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:

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

For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

Caution: 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”
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
         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; general increase in technical depth
       “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
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
◊ Drive safely along Partizanska?
Which of the following can be done at present?

◊ Play a decent game of table tennis
◊ Drive safely along a curving mountain road
◊ Drive safely along Partizanska
◊ Buy a week’s worth of groceries on the web
State of the art

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♦ Drive safely along a curving mountain road
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♦ Play a decent game of bridge
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◊ Drive safely along a curving mountain road
◊ Drive safely along Partizanska
◊ Buy a week’s worth of groceries on the web
◊ Buy a week’s worth of groceries at Zelen pazar
◊ Play a decent game of bridge
◊ Discover and prove a new mathematical theorem
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◊ Buy a week’s worth of groceries at Zelen pazar  
◊ Play a decent game of bridge  
◊ Discover and prove a new mathematical theorem  
◊ Design and execute a research program in molecular biology
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♦ Design and execute a research program in molecular biology
♦ Write an intentionally funny story
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◊ Give competent legal advice in a specialized area of law
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◊ Translate spoken English into spoken German in real time
State of the art

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◊ Give competent legal advice in a specialized area of law
◊ Translate spoken English into spoken German in real time
◊ Converse successfully with another person for an hour
Which of the following can be done at present?

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- Design and execute a research program in molecular biology
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- Converse successfully with another person for an hour
- Perform a complex surgical operation
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◊ 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 German in real time
◊ Converse successfully with another person for an hour
◊ Perform a complex surgical operation
◊ Unload any dishwasher and put everything away
State of the art

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♦ Perform a complex surgical operation
♦ Unload any dishwasher and put everything away
Summary

• Different people think of AI differently. Two important questions to ask are: Are you concerned with thinking or behavior? Do you want to model humans or work from an ideal standard?

• We adopt the view that intelligence is concerned mainly with rational action. Ideally, an intelligent agent takes the best possible action in a situation. We will study the problem of building agents that are intelligent in this sense.

• Philosophers (going back to 400 B.C.) made AI conceivable by considering the ideas that the mind is in some ways like a machine, that it operates on knowledge encoded in some internal language, and that thought can be used to choose what actions to take.
Mathematicians provided the tools to manipulate statements of logical certainty as well as uncertain, probabilistic statements. They also set the groundwork for understanding computation and reasoning about algorithms.

Economists formalized the problem of making decisions that maximize the expected outcome to the decision-maker.

Psychologists adopted the idea that humans and animals can be considered information-processing machines. Linguists showed that language use fits into this model.

Computer engineers provided the artifacts that make AI applications possible. AI programs tend to be large, and they could not work without the great advances in speed and memory that the computer industry has provided.
The history of AI has had cycles of success, misplaced optimism, and resulting cutbacks in enthusiasm and funding. There have also been cycles of introducing new creative approaches and systematically refining the best ones.

AI has advanced more rapidly in the past decade because of greater use of the scientific method in experimenting with and comparing approaches.

Recent progress in understanding the theoretical basis for intelligence has gone hand in hand with improvements in the capabilities of real systems. The subfields of AI have become more integrated, and AI has found common ground with other disciplines.