Artificial Intelligence

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CSE 440

Introduction

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Artificial Intelligence

Studies how to achieve intelligent behavior through computational means.

This makes AI a branch of Computer Science.

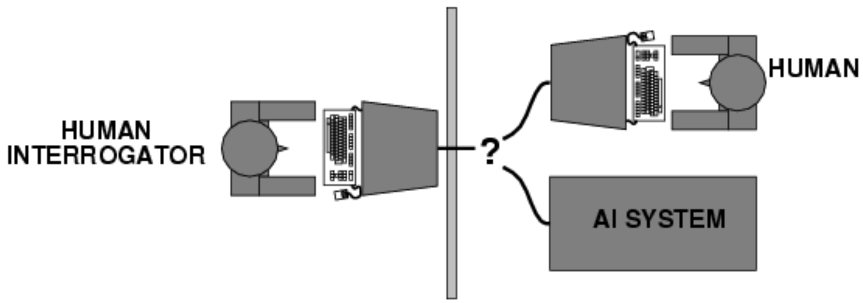
Why do we think that intelligence can be captured through computation?

Modeling the processing that our brains do as computation has proved to be successful. Hence, human intelligence can arguably be best modeled as a computational process.

Classical Test of (Human) Intelligence

The Turing test

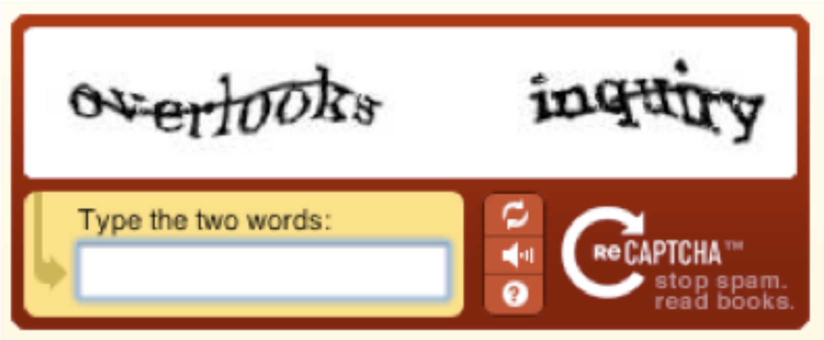
A human interrogator. Communicates with a hidden subject that is either a computer system or a human.



If the human interrogator cannot reliably decide whether or not the subject is a computer, the computer is said to have passed the Turing test.

Classical Test of (Human) Intelligence

Weak Turing Test



See Luis von Ahn, Manuel Blum, Nicholas Hopper, and John Langford. CAPTCHA: Using Hard AI Problems for Security. In Eurocrypt.

Human Intelligence

- Turing provided some very persuasive arguments that a system passing the Turing test

  is intelligent.
  - We can only really say it ***behaves like a human***
  - Nothing guarantees that it thinks like a human

- The Turing test does not provide much traction on the question of how to actually build an intelligent system.

Human Intelligence

- Recently some claims have been made of AI systems that can pass the Turing Test.
- However, these systems operate on subterfuge, and were able to convince a rather naïve jury that they were human like.
- The main technique used is obfuscation… rather than answering questions the system changed the topic!
- This is not what Turing described in his Turing Test.

Human Intelligence

- In general there are various reasons why trying to mimic humans might **not** be the best approach to AI:
  - Computers and Humans have a very different architecture with quite different abilities.
  - Numerical computations
  - Visual and sensory processing
  - Massively and slow parallel vs. fast serial

Human Intelligence

	Computer	Human Brain
Computational Units	8 CPUs, 10^{10} gates	10^{11} neurons
Storage Units	10^{10} bits RAM 10^{13} bits disk	10^{11} neurons 10^{14} synapses
Cycle time	10^{-9} sec	10^{-3} sec
Bandwidth	10^{10} bits/sec	10^{14} bits/sec
Memory updates/sec	10^{10}	10^{14}

Human Intelligence

- But more importantly, we know very little about how the human brain performs its higher level processes. Hence, this point of view provides very little information from which a scientific understanding of these processes can be built.
- Nevertheless, Neuroscience has been very influential in some areas of AI. For example, in robotic sensing, vision processing, etc.
- Humans might not be best comparison?
  - Don’t always make the best decisions
  - Computer intelligence can aid in our decision making

Rationality

- The alternative approach relies on the notion of rationality.
- Typically this is a precise formal notion of what it means to *do the right thing* in any particular circumstance. Provides
  - A precise mechanism for analyzing and understanding the properties of this ideal behavior we are trying to achieve.
  - A precise benchmark against which we can measure the behavior the systems we build.

Rationality

- Formal characterizations of rationality have come from diverse areas like logic (laws of thought) and economics (utility theory—how best to act under uncertainty, game theory how self-interested agents interact).
- There is no universal agreement about which notion of rationality is best, but since these notions are precise we can study them and give exact characterizations of their properties, good and bad.
- We'll focus on acting rationally
  – this has implications for thinking/reasoning

Computational Intelligence

- *AI tries to understand and model intelligence as a computational process.*
- Thus we try to construct systems whose computation achieves or approximates the desired notion of rationality.
- Hence AI is part of Computer Science.
  - Other areas interested in the study of intelligence lie in other areas or study, e.g., cognitive science which focuses on human intelligence. Such areas are very related, but their central focus tends to be different.

Rational Decision

We'll use the term **rational** in a very specific, technical way:

- Rational: maximally achieving pre-defined goals
- Rationality only concerns what decisions are made
  (not the thought process behind them)
- Goals are expressed in terms of the **utility** of outcomes
- Being rational means **maximizing your expected utility**

A better title for this course would be:

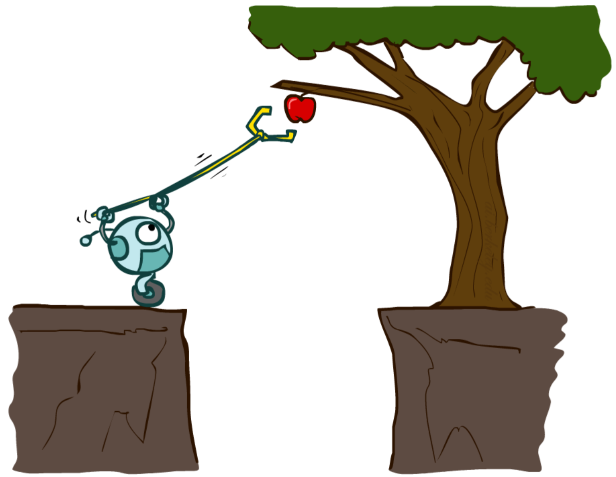
Computational Rationality

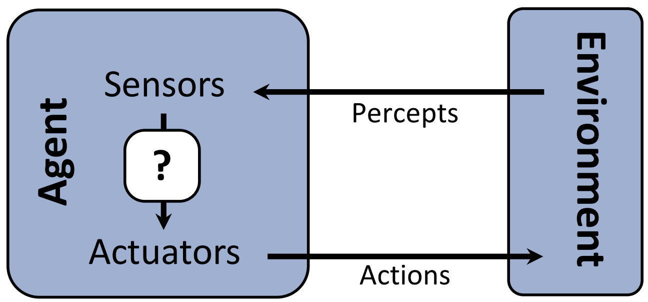
AI Definitions

The science of making machines that:

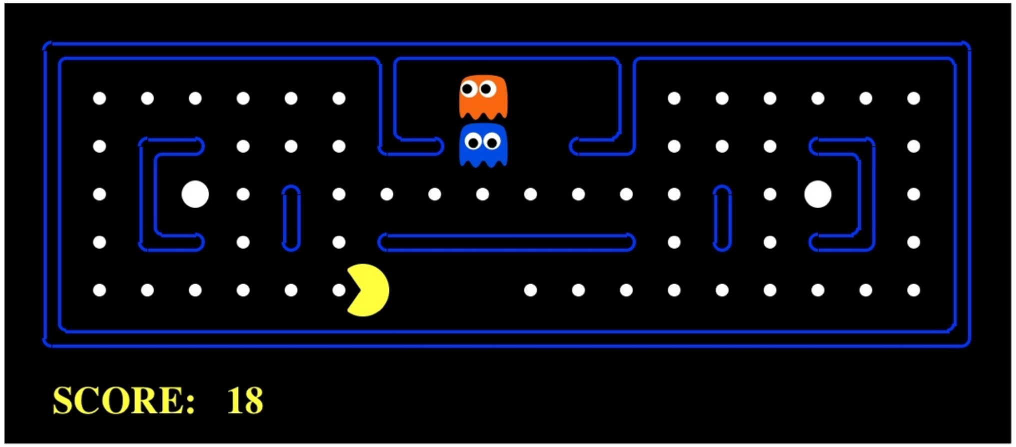
Designing Rational Agents

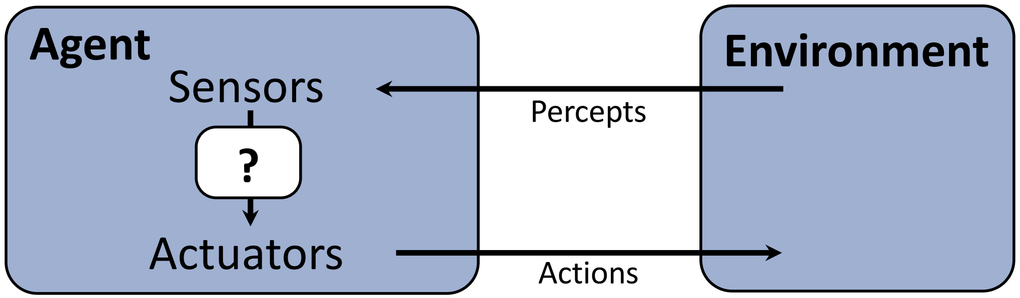
- An **agent** is an entity that *perceives* and *acts*.
- A **rational agent** selects actions that maximize its (expected) **utility**.
- Characteristics of the **percepts, environment,** and **action space** dictate techniques for selecting rational actions
- **This course** is about:
  - General AI techniques for a variety of problem types
  - Learning to recognize when and how a new problem can be solved with an existing technique





Pac-Man as an Agent





Pac-Man is a registered trademark of Namco-Bandai Games, used here for educational purposes

Subareas of AI

- Perception: vision, speech understanding, etc.
- Machine Learning, Neural networks
- Robotics
- Natural language processing
- Reasoning and decision making
  - Knowledge representation
  - Reasoning (logical, probabilistic)
  - Decision making (search, planning, decision theory)

Subareas of AI

- Many of the popular recent applications of AI in industry have been based on Machine Learning, e.g., voice recognition systems on your cell phone.
- We will not say much in this course about machine learning, although the last part of the course will introduce Bayes Networks a form of probabilistic graphical model.
- Probabilistic graphical models are fundamental in machine learning.

Subareas of AI

- Nor will we discuss Computer Vision nor Natural Language to any significant extent.
- All of these areas have developed a number of specialized theories and methods specific to the problems they study.
- The topics we will study here are fundamental techniques used in various AI systems, and often appear in advanced research in many other sub-areas of AI.
- In short, what we cover here is not sufficient for a deep understanding of AI, but it is a good start.

AI Successes

- Games: chess, checkers, poker, bridge, backgammon…
  - Search
- Physical skills: driving a car, flying a plane or helicopter, vacuuming...
  - Sensing, machine learning, planning, search, probabilistic reasoning
- Language: machine translation, speech recognition, character recognition, …
  - Knowledge representation, machine learning, probabilistic reasoning
- Vision: face recognition, face detection, digital photographic processing, motion tracking, …
- Commerce and industry: page rank for searching, fraud detection, trading on financial markets…
  - Search, machine learning, probabilistic reasoning

Recent AI Successes

- Darpa Grand Challenges
  - Goal: build a fully autonomous car that can drive a 240 km course in the Mojave desert
  - 2004: none went further than 12 km
  - 2005: 5 finished
  - 2007: Urban Challenge: 96 km urban course (former air force base) with obstacles, moving traffic, and traffic regulations: 6 finishers
  - 2011: Google testing its autonomous car for over 150,000 km on real roads
- 2011: IBM Watson competing successfully against two Jeopardy grand-champions

Degrees of Intelligence

- Building an intelligent system as capable as humans remains an elusive goal.
- However, systems have been built which exhibit various specialized degrees of intelligence.
- Formalisms and algorithmic ideas have been identified as being useful in the construction of these "intelligent" systems.
- Together these formalisms and algorithms form the foundation of our attempt to understand intelligence as a computational process.
- In this course we will study some of these formalisms and see how they can be used to achieve various degrees of intelligence.

History of AI

- 1943 McCulloch & Pitts: Boolean circuit model of brain
- 1950 Turing's "Computing Machinery and Intelligence"
- 1956 Dartmouth meeting: "Artificial Intelligence" adopted
- 1950s Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
- 1965 Robinson's complete algorithm for logical reasoning
- 1966—73 AI discovers computational complexity
  Neural network research almost disappears
- 1969—79 Early development of knowledge-based systems
- 1980— AI becomes an industry
- 1986— Neural networks return to popularity
- 1987— AI becomes a science
- 1995— The emergence of intelligent agents
- 2003— Human-level AI back on the agenda