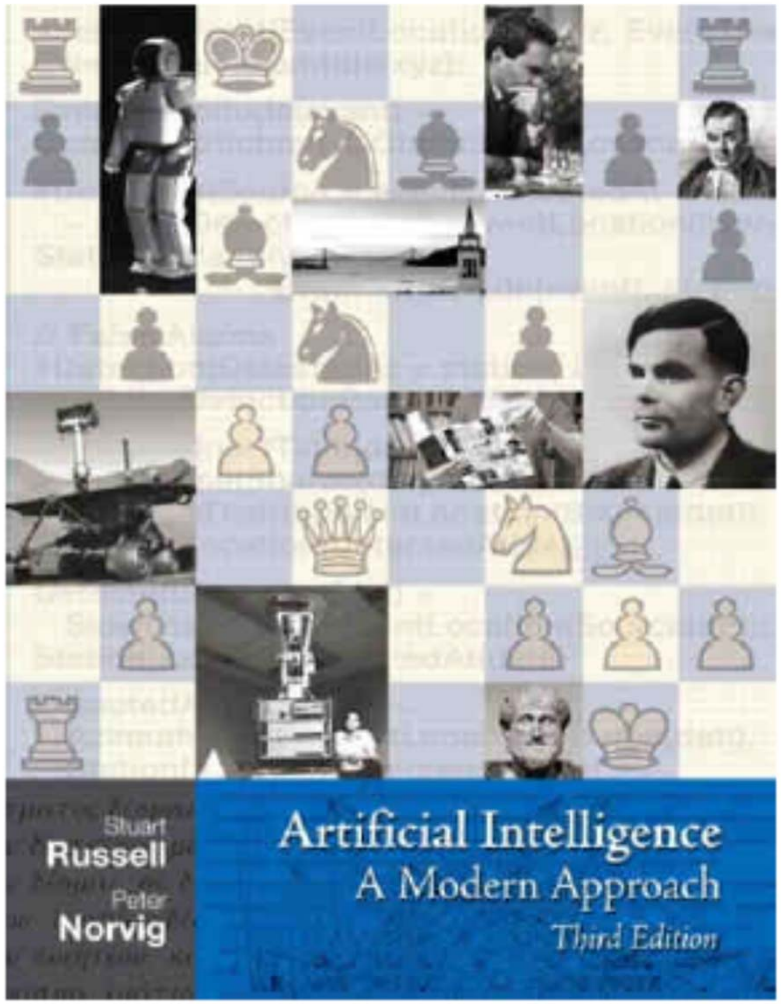
CSE 537 – Artificial Intelligence
Learning Objectives

To introduce you to a set of key:

- –Concepts &
- –Techniques in AI

Textbook:

Russell & Norvig. “Artificial Intelligence: A Modern Approach”, 3nd ed.



Lecture notes (slides)

- Available on Blackboard

Evaluation:

– 4 to 5 programming assignments (20%)
– Unannounced pop quizzes (up to 5%)
– Midterm (30%)
– Final exam (45% to 50%)

The % are approx. and may change

Policies

- All Projects/Reports must be submitted on the due dates unless explicitly given a deadline extension
- All projects must be done independently.
- There will be no tolerance for plagiarized code and project reports. Code will be subjected to automatic plagiarism detection. Students who submitted plagiarized code/reports will receive **F** in the course.

Topics

- Search
  - Uninformed
  - Informed
- Adversarial Games
  - Minimax
  - Alpha-Beta Pruning
- Constraint Satisfaction Problems
- Knowledge Representation and Reasoning
  - Propositional Logic
  - Predicate Logic
  - Prolog
- Reasoning under Uncertainty
  - Probability and Random Processes
  - Bayesian Networks
- Machine Learning
  - Supervised Learning
  - Unsupervised Learning
  - Reinforcement Learning
- Density estimation
  - Maximum Likelihood Estimation
  - Expectation Maximization
- Decision Making
  - Markov Decision Process
- Reasoning with Temporal Sequences
  - Hidden Markov Models
- Speech And NLP Applications
- Planning

The last two topics will be covered if time permits.

What is AI

Some informal answers:

– Modeling human cognition using computers.

– Doing **cool** stuff!

• Game playing, machine learning, data mining, speech recognition, computer vision, web agents, robots.

– Doing **useful** stuff!

• Medical diagnosis, fraud detection, genome analysis, object identification, space shuttle scheduling, information retrieval.

What is AI

- "The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990).

- "The branch of computer science that is concerned with the automation of intelligent behavior." (Luger and Stublefield, 1993)

What is AI

The Science of making Machines for:

Thinking Humanly	Thinking Rationally
Acting Humanly	Acting Rationally

What is AI

- Thinking Humanly – to think like humans; involves cognitive sciences – psychology, neuroscience
- Acting Humanly – the Turing test: pose questions whose responses fail to distinguish between humans and machines (needs major advances)
- Thinking Rationally – reduces human reasoning to axioms and deducing using rules of inference. Emphasis is on correct conclusions (not all knowledge can be codified, knowledge is incomplete, noisy, etc.)
- Acting Rationally – to take actions so as to achieve the best possible outcome or best possible expected outcome, in case of uncertainty

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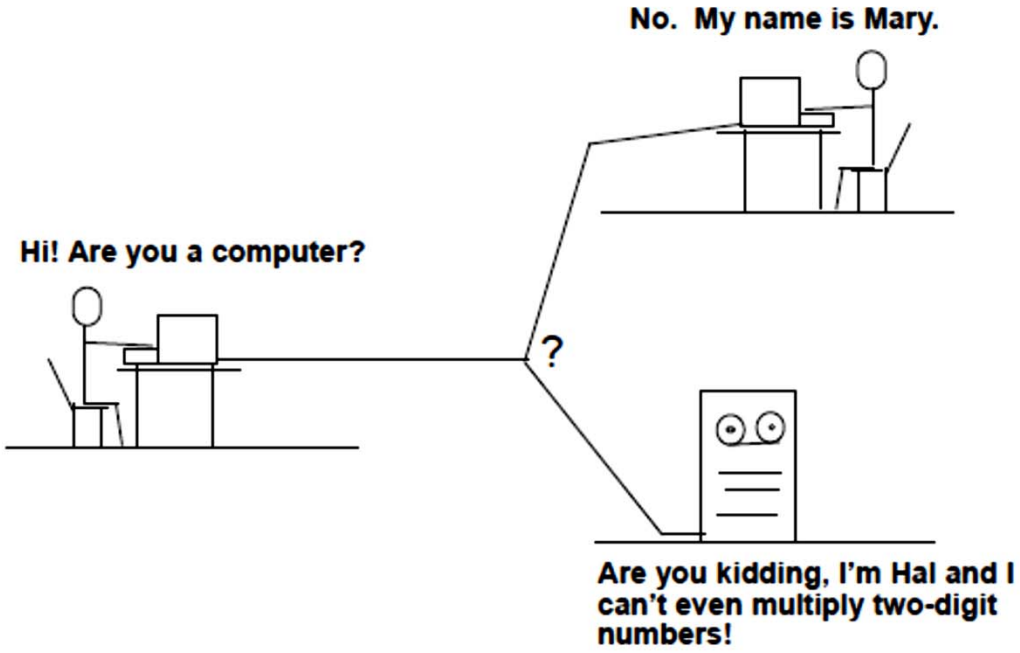

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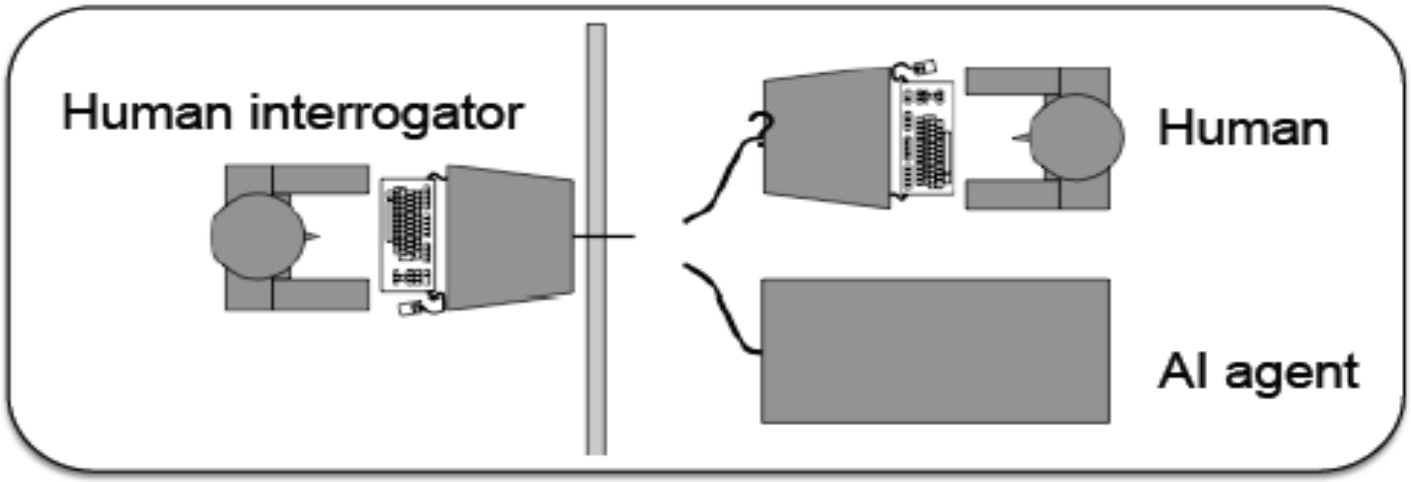
AI is about duplicating what the (human) brain DOES.

- Alan Turing (1912-1954) had interesting thoughts about this:

Can a machine think? -> If it could, how would we tell?

Turing (1950): "Computing machinery and intelligence"



An operator interacts with either the human or the AI agent.

Can he correctly guess which one?

Turing Test

– AI researchers have spent little effort on the Turing test.

– Turing test is not *reproducible* or amenable to *mathematical analysis*.

– More important to study underlying principles of intelligence than trying to duplicate human intelligence.

Here's a thought: Quest for "artificial flight" succeeded when we stopped trying to imitate birds, and started learning about aerodynamics.

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Acting Rationally

Rational behavior = doing the "right" thing.

• Doing what is expected to **maximize goal achievement**, given the **available information** and **available resources**.

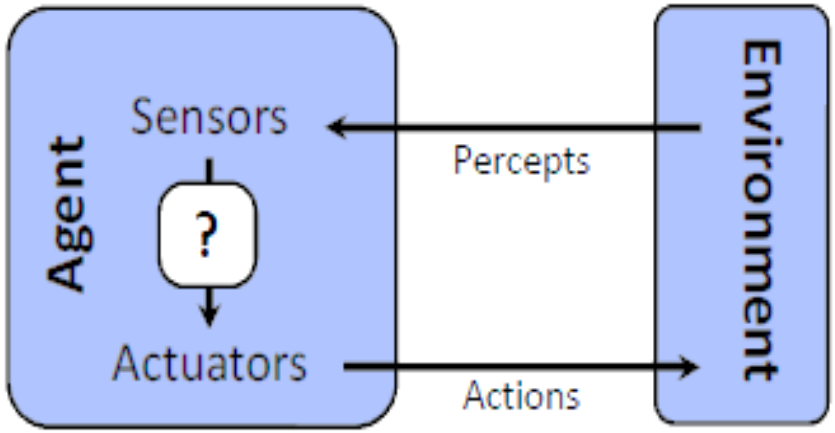
– Does not necessarily require thinking (e.g. blinking reflex). Only concerns what decisions are made (not the thought process behind them)

– But in many cases, thinking serves rational behavior.

- Goals are expressed in terms of the **utility** of outcomes
- Being rational means **maximizing your (expected) utility**

Enacting "Acting Rationally"

- 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 designing **rational agents**.

Goal: Learn a function mapping *percept histories* to *actions*: $f : Ph \rightarrow A$

- A rational agent implements this function such as to maximize performance.

  – Performance measures: goal achievement, resource consumption, ...

- **Caveat**: Many constraints can come into play (time, space, energy, bandwidth, …) which make perfect rationality unachievable.

Objective: Find best function for given information and resources.

We will study general AI techniques for rational agents:
for a variety of problem types and learn to recognize when and how a new problem can be solved with an existing technique.

Teach you to identify when & how to use

- Heuristic search for problem solving and games
- Logic for knowledge representation and reasoning
- Probabilistic inference for reasoning under uncertainty
- Decision Making, Utility and Game Theory
- Planning
- Machine learning (for pretty much everything)

Brief History of AI

1943 McCulloch & Pitts: Boolean circuit model of the brain
1950 Turing's ``Computing Machinery and Intelligence'' paper
1950's Early AI programs: *Samuel's checkers program*
Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
1956 Dartmouth meeting: ``Artificial Intelligence'' adopted
1960's Fast progress on reasoning via search, theorem proving, planning.
1970's AI hits some roadblocks: computational complexity, need for domain knowledge, limited representational power. The "AI Winter"
1980's The rise (and fall) of knowledge-based expert systems.
Second age of neural networks.
1990's Greater emphasis on the scientific method. Interest in probabilistic and decision-theoretic methods. Data mining becomes an industry. The "AI Spring" begins.
2000's AI systems underlie many tools. Access to large datasets puts emphasis on machine learning.
2010's Wide-scale deployment of applied AI systems: robotics, natural language Processing, automatic speech recognition, text-to- speech synthesis web agents, trading agents.

Example AI system (1997): Chess playing

IBM Deep Blue defeats Garry Kasparov.

- Perception: advanced features of the board.
  Actions: choose a move.
- Reasoning: search and evaluation of
  possible board positions.

Example AI system (2011): Jeopardy!

Top 100 Stories of 2011 #3: A Supercomputer Wins Jeopardy!

Perception: Takes in a question in text
Actions: generate answer in text
Reasoning: Probabilistic Knowledge+NLP

Algorithms Take Control of Wall Street

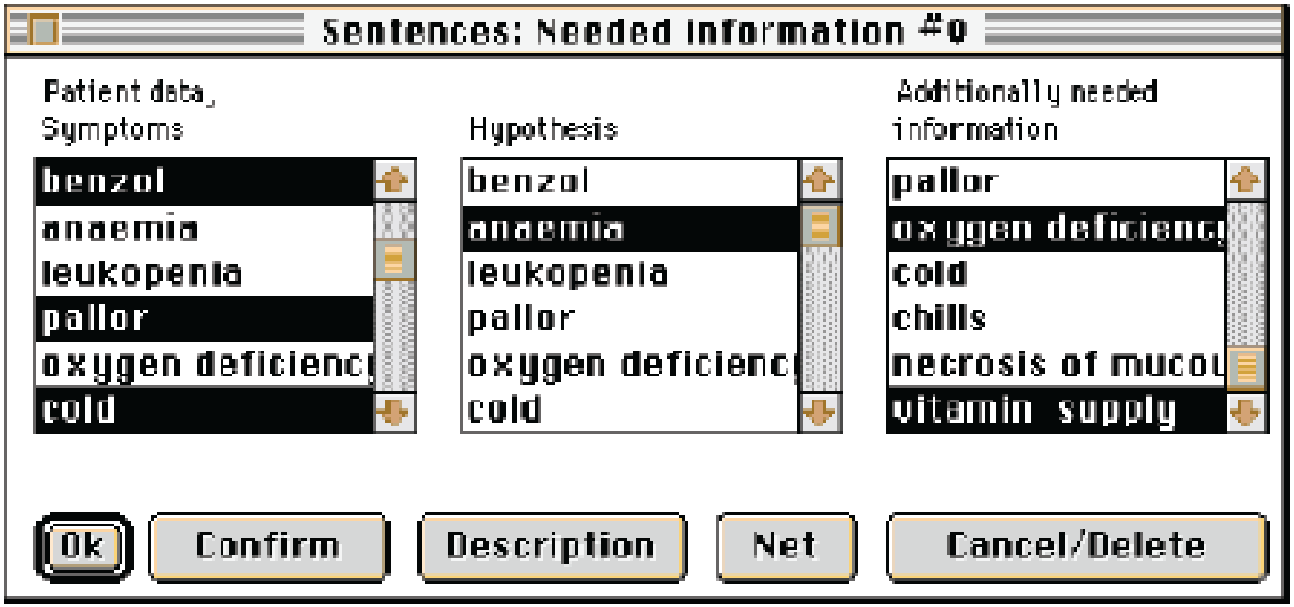
By Felix Salmon and Jon Stokes ✉ December 27, 2010 | 12:00 pm | Wired January 2011

Today Wall Street is ruled by thousands of little algorithms, and they've created a new market—volatile, unpredictable, and impossible for humans to comprehend.
Photo: Mauricio Alejo

Example AI system (1992): Medical diagnosis

Pathfinder (D. Heckerman, Microsoft Research)

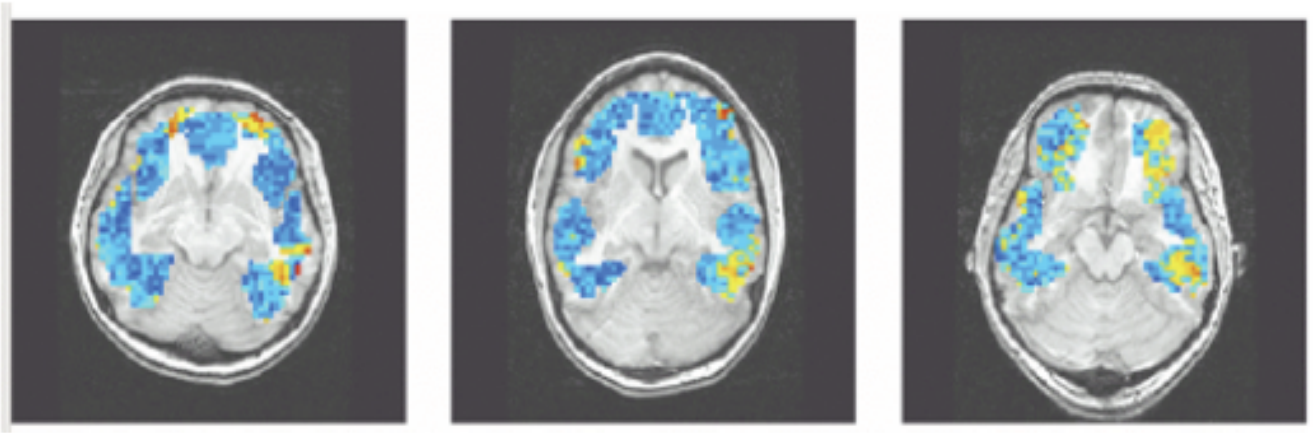
- Perception: symptoms, test results.
- Actions: suggest tests, make diagnosis.
- Reasoning: bayesian inference, machine learning, Monte-Carlo simulation.



Example AI system (2008): Reading the Mind

Brain Image Analysis (T. Mitchell, CMU)

- Perception: brain imaging using fMRI technology.
- Actions: detect which word (e.g. “hammer”, “apartment”, …) is being read by the human subject.
- Reasoning: statistical machine learning.



Example AI system (1998): Automatic driver

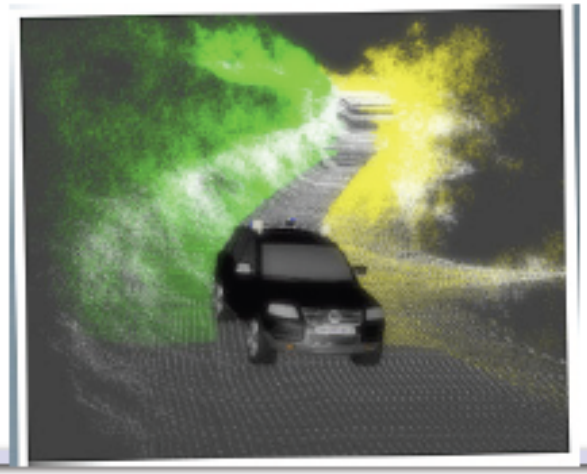
ALVINN (D. Pomerleau, CMU) drives autonomously for 21 miles on the highway at speeds of up to 55 miles/hour.

- Perception: digitized camera images of the road.
- Actions: 64 steering angles.
- Reasoning: artificial neural network.

Example AI system (2005): Off-road driving

Stanley (Stanford University) navigates 132 miles through desert terrain in less than 10 hours, with no human intervention.

- Perception: GPS, 6-D inertial measurement, wheel speed, 4 lasers, 1 radar, stereo and monocular cameras.
- Actions: actuation of drive-by-wire system.
- Reasoning: position estimation, path planning.



http://cs.stanford.edu/group/roadrunner//old/index.html

AI and the Web

- Web crawling, search engines, information retrieval.
- Exploiting web-based content for other tasks: translation, text summarization, fact checking.
- Social networking, trend spotting.
- Recommendation systems.
- Etc.