

CS 1571 Introduction to AI

Lecture 1

Course overview

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Course web page:

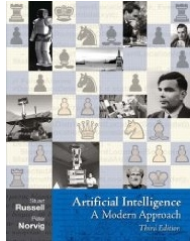
<http://www.cs.pitt.edu/~milos/courses/cs1571/>

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Textbook

Course textbook:



Stuart Russell, Peter Norvig.
Artificial Intelligence: A modern approach.
3rd edition, Prentice Hall, 2009

Other widely used AI textbooks:

Dean, Allen, Aloimonos: Artificial Intelligence.
P. Winston: Artificial Intelligence, 3rd ed.
N. Nilsson: Principles of AI.

Grading

- | | |
|------------------------|-----|
| • Lectures | 10% |
| • Homework assignments | 45% |
| • Midterm | 20% |
| • Final | 25% |

Lectures

- **10 % of the grade**
- **Attendance + activity**
- **3-4 short quizzes**
 - 10 minutes at the beginning of the lecture
 - Random
 - Short question(s) from previous lectures

Homework assignments

- **Homework assignments:**
 - 45 % of the grade
 - Weekly assignments
 - A mix of pencil and paper, and programming assignments
 - No extensions. Homework due dates are strict.
- **Collaborations:**
 - No collaborations on homework assignments
- **Programming language:**
 - C/C++
 - g++ compiler under UNIX

Exams

- **Midterm**
 - 20 % of the grade
 - In-class
- **Final**
 - 25 % of the grade
 - Cumulative exam with focus on the second half of the course

Academic honesty

- All the work in this course should be **done independently**.
- **Collaborations on homework assignments, quizzes and exams are not permitted.**
- Cheating and any other anti-intellectual behavior, including giving your work to someone else, will be dealt with severely.
- **Academic Integrity Code** for the Faculty and College of Arts and Sciences: <http://www.as.pitt.edu/fac/policies/academic-integrity>

Artificial Intelligence

- The field of **Artificial intelligence**:
 - The design and study of computer systems that behave intelligently
- **AI programs**:
 - Go beyond numerical computations and manipulations
 - Focus on problems that require reasoning (intelligence)
- **Why is AI research important?**
 - Engineering aspect
 - solving of hard problems
 - Cognitive aspect
 - Understanding the nature of human intelligence

Intelligence and machines

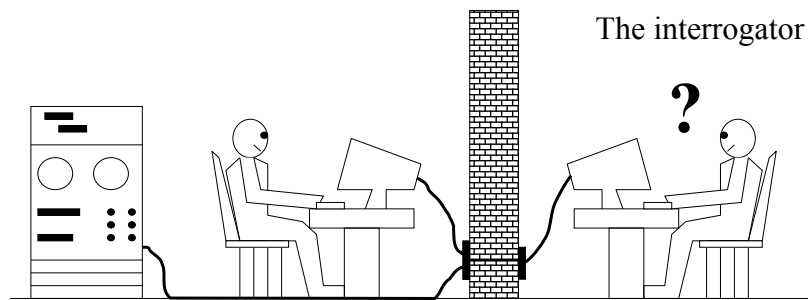
Can we make machines intelligent?

- **Symbolic system hypothesis** (Newell and Simon)
 - Intelligence is substrate neutral;
 - A physical symbol system has necessary and sufficient means for general intelligent action.
- **Biological substrate only** (John Searle, philosopher).
 - Intelligence is substrate dependent. The material humans are made of is fundamental for our intelligence. Thinking is possible only in special machines – living ones made of proteins.
- Other researchers believe that **sub-symbolic processing** (signal processing) may be needed to replicate intelligence.

Turing test

How to test the “intelligence” of a program?

- **Behavioral view of intelligence**
 - A behavior capable of fooling a human interrogator



- Acting humanly is sufficient to pass the test.
- Is it necessary the AI system also thinks humanly?

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Eliza program

- **Eliza, a computer therapist**, created by Joseph Weizenbaum in 1966 at MIT, is one of the most famous early AI programs.
- Eliza functions by "twisting the statements of her 'patients' back at them in the classic manner of a non-directive psychotherapist."
- The fact that it understands the subject's statements is an illusion. Surprisingly, many users were taking its performance quite seriously.
- **You can run Eliza at:**
 - <http://www-ai.ijs.si/eliza/eliza.html>
- **Info:**
 - <http://web.mit.edu/STS001/www/Team7/eliza.html>

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Eliza program. Sample dialogue.

Eliza: Hello. I am ELIZA. How can I help you?

You: I am frustrated by the traffic I have to face every morning.

Eliza: How long have you been frustrated by the traffic you have to face every morning?

You: For about a year now.

Eliza: Please go on.

You: Why should I go on? Give me some advice.

Eliza: Can you elaborate on that?

You: Why? Give me some solution.

Eliza: Can you elaborate on that?

You: It is obvious you cannot pass the Turing test

Eliza: Oh, i cant pass the turing test.

You: That is correct.

Eliza: Please go on.

...

Try it yourself at: <http://www-ai.ijs.si/eliza/eliza.html>

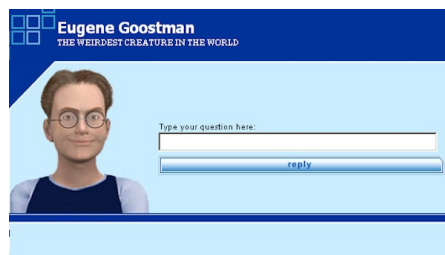
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Passing the Turing test

Turing Test in recent news: June 6, 2014

- A computer program that pretends to be a 13-year-old Ukrainian boy called Eugene Goostman passed a Turing test at the Royal Society in London on June 6, 2014 by convincing 33 percent of the judges that it was human during a five-minute typed conversation.



- <http://www.princetonai.com/bot/bot.jsp>

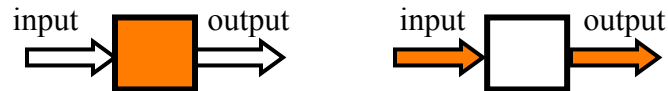
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Evaluation of an AI system

Depends on what matters more.

•Reasoning vs. Behavior



- the **computational process** or the **end-product** matters

•Human performance vs. Rationality

- Compare against human model (with its weaknesses) or a **normative “ideal”** model (rational system)

RN textbook

- The textbook adopts the **rational agent perspective**
Focus on Behavior and rational (normative) models

- **Agent:** an entity that perceives and acts
 - On abstract level the agent maps percepts to actions

$$f : \textit{Percepts} \rightarrow \textit{Actions}$$

- **Design goal:** for any given environment find the agent that performs the best with respect to some normative model
- **Caveat:** The design may be limited by resources: memory, time
 - Find agents with best resource-performance trade-off

History of AI

- **Artificial Intelligence** – name adopted at Dartmouth conference in 1956
- “Contemporary” AI starts in 20th century (1940s),
But the origins go back many years.

Origins of AI:

- **Artificial people.**
 - Beings or devices capable of substituting or replacing humans in various activities.
- **Mathematical models of reasoning.**
 - Formal models of thought and reasoning.

Artificial people

- Beings or devices capable of substituting or replacing humans in various activities
- **Legends, stories:**
 - **Androids** (artificial people):
 - Android constructed by Albert the Great (13-th century)
 - Golem: made from clay, household chores (14-th century)
 - **Homunkulus** – a human-like being created in other than natural way (Paracelcus, 16-th century)
- **Mechanical people** capable of writing, drawing, playing instruments (18-th century)
- **Kempelen's chess machine** (18-th century).
- **Robots.** Drama R.U.R. by K. Capek (early 20th century)

Mathematical models of reasoning.

- Philosophers and mathematicians worked on **models of reasoning and thought**.
- **Aristotle** (384-322 B.C), ancient Greece, philosopher
 - Tried to explain and codify certain types of **deductive reasoning** he called syllogisms.
- **George Boole** (1854)
 - Foundations of **propositional logic**.
 - Formal language for making logical inferences.
- **Gottlieb Frege** (end of 19-th century).
 - **First order logic**

The beginnings of AI (40s-50s).

Two streams:

- **Neural network approach** (McCulloch and Pitts 1943).
 - Models of a human brain.
- **Computer programs** capable of **simple reasoning tasks**:
 - chess programs (Shannon 1950, Newell, Shaw & Simon 1958)
 - checkers (Samuel 1959)
 - Theorem prover in geometry (Gelernter 1959)
 - Logic Theorist (Newell, Shaw & Simon 1957). Used propositional logic to prove theorems.
- **Dartmouth meeting (1956)**, the name **Artificial Intelligence** adopted (due to John McCarthy)

60s.

Developments in the two streams:

- **Neural network models for learning patterns and pattern recognition**
 - **Objective:** replicate self-organization and subsequently phenomenon intelligence
 - Build on McCulloch and Pitts' work (1943)
 - **Adaline networks** (Widrow, Hoff 1960)
 - **Perceptrons** (Rosenblatt 1961)
 - Minsky and Papert (1969) – strong critique of perceptrons, it killed the area for a decade
- **Symbolic problem solvers:**
 - **General problem solver** (Newell, Simon) – think humanly
 - **LISP** – AI-specific programming language
 - **Micro-worlds** – focus on problem-solving in restricted worlds (e.g. blocks world)

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70s. Knowledge-based system era.

- Early AI systems did not scale-up well to large applications
- The need for background knowledge

Edward Feigenbaum: “**knowledge is the power**”

Power of the system derived from the knowledge it uses

- Expert systems: obtain the knowledge from experts in the field, and replicate their problem-solving

Examples of KB systems:

- **Dendral** system (Buchanan et al.). Molecular structure elicitation from mass spectrometer readings.
- **Mycin.** Diagnosis of bacterial infections.
- **Internist** (Pople, Myers, Miller). Medical diagnosis.

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80s. AI goes commercial.

AI becomes an industry

- Many tools for the design of KB systems were developed

Revival of neural network (connectionist) approach.

- **Multi-layer neural networks**
 - Modeling and learning of non-linear functions.
 - Back-propagation algorithm (learning)

Failure of AI in 80s

- High expectations in very short time
- Computational complexity: some problems are intrinsically hard
- Modeling uncertainty
- Separation of connectionist - logic approaches.

90s. Moving ahead

- **Modeling uncertainty** (a breakthrough in late 80s)
 - Bayesian belief networks, graphical models.
 - Speech recognition.
- **Machine learning and data mining**
 - Analysis of large volumes of data
 - Finding patterns in data
 - Learning to predict, act
- **Autonomous agents** with intelligence:
 - Software agents
 - Robots

AI today

AI is more rigorous and depends strongly on: applied math, statistics, probability, control and decision theories

Recent advances:

- Machine Learning and Data mining
- Image analysis and vision
- Natural language processing
- Optimization
- Robotics

Applications:

- **Achieve partial intelligence** (not all human capabilities)
- Systems with components of intelligence in a specific application area;

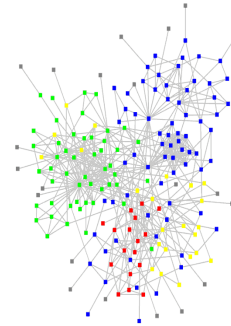
AI applications: Software systems.

- **Diagnosis of:** software, technical components
- **Adaptive systems**
 - Adapt systems to user needs
 - Adapt systems to specific tasks
- **Examples:**
 - Intelligent interfaces
 - Intelligent helper applications
 - Collaborative filtering
 - Target advertising

Search and information retrieval

Web search engines

- Improve the quality of search
- Rely on methods/algorithms developed in AI
- Add inferences and knowledge to search queries



Semantic web (or web 2):

- From information to knowledge sharing
- Ontology languages

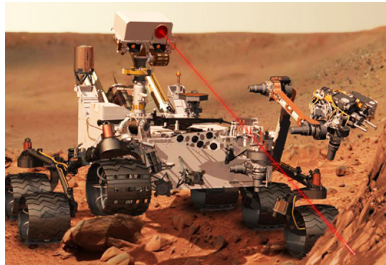
Speech recognition

- **Speech recognition systems:**
 - Systems based on statistical models,
 - Hidden Markov models
- **Multi-user speech recognition**
- Voice command/voice activated devices
 - No training – works for many users
- **Adaptive speech systems**
 - Adapt to the user (training)
 - continuous speech
 - commercially available software – (Nuance, IBM)
 - <http://www.nuance.com/>

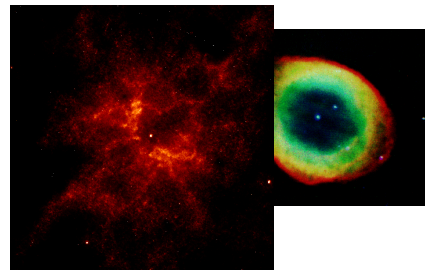


Space exploration

Autonomous rovers,
intelligent probes



Analysis of sky
Survey data

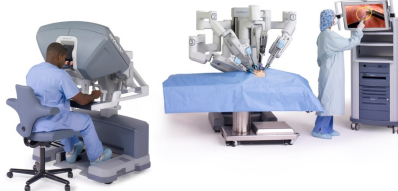
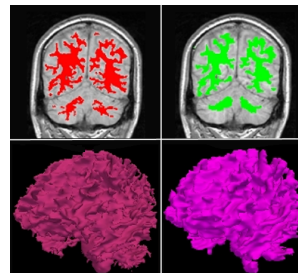
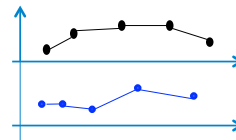


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AI applications: Medicine

- **Medical diagnosis:**
 - QMR system. Internal medicine.
- **Patient Monitoring and Alerting:**
 - Cerner
- **Medical imaging**
 - Classification of body structures and visualization
- **Robotic surgeries**

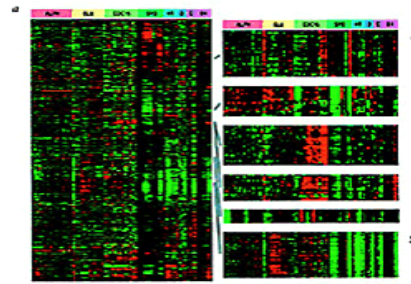
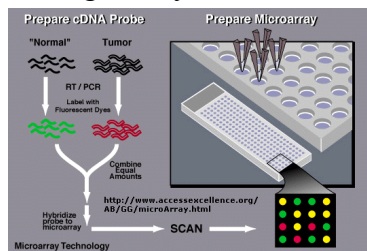


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AI applications: Bioinformatics

- **Genomics and Proteomics**
 - Sequence analysis
 - Prediction of gene regions on DNA
 - Analysis of DNA micro-array and proteomic MS profiles: find genes, proteins (peptides) that characterize a specific disease
 - Regulatory networks



Example of a microarray used in gene sequencing

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AI applications: Transportation

Autonomous vehicle control:

- ALVINN (CMU, Pomerleau 1993)
- Series of DARPA challenges (<http://www.grandchallenge/>)
 - 2004, 2005 Drive across Mojave
 - 2007 - DARPA Urban Challenge
- Google autonomous vehicles



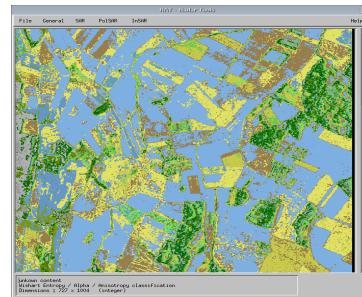
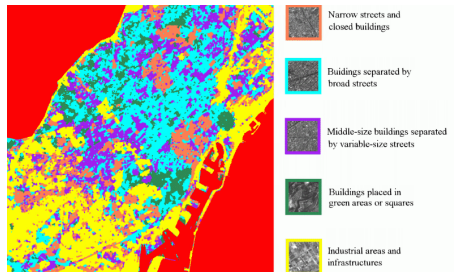
- **Pedestrian detection**
- **Traffic monitoring**
- **Navigation/route optimizations**



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Classification of images or its parts



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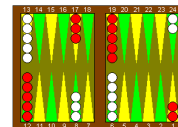
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Game playing

- **Backgammon**

- TD-backgammon

- a program that learned to play at the championship level (from scratch).
 - reinforcement learning



- **Chess**

- Deep blue (IBM) program (defeated Kasparov in 1997)



- **Bridge, Poker**



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Natural language processing

understanding/annotation of free text

•Document analysis:

- Automatic classification of articles
- Content extraction/inference
- Email SPAM detection

•IBM's Watson project

- www.ibm.com/watson
- Successfully competed against the top human players in Jeopardy!



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Robots

• Robotic toys

- Sony's Aibo



• Vacuum cleaners



• Humanoid robot

- Honda's ASIMO

(<http://world.honda.com/robot/>)



• Military robots



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Other application areas

- **Handwriting analysis/ detection**
- **Human face detection**
- **Video stream annotation**
- **Object tracking**
- **Music composition, picture drawing**
- ...

Topics

- **Problem solving and search.**
 - Formulating a search problem, Search methods, Combinatorial and Parametric Optimization.
- **Logic and knowledge representations.**
 - Logic, Inference
- **Planning.**
 - Situation calculus, STRIPS, Partial-order planners,
- **Uncertainty.**
 - Modeling uncertainty, Bayesian belief networks, Inference in BBNs, Decision making in the presence of uncertainty.
- **Machine Learning**
 - Supervised learning, unsupervised learning, Basic learning models