

CS 2710 Foundations of AI

Lecture 1

Course overview

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Course administrivia

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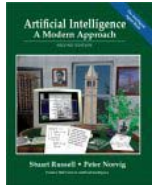
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Course web page:

<http://www.cs.pitt.edu/~milos/courses/cs2710/>

Textbook

Course textbook:



Stuart Russell, Peter Norvig.

Artificial Intelligence: A modern approach.

2nd edition, Prentice Hall, 2002

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 + short quizzes**
- **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
 - Covers whole semester
- **AI prelim exam:**
 - AI prelim = CS 2710 final (last year)

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.fcas.pitt.edu/academicintegrity.html>

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 reasoning tasks that require intelligence
- **Aspects of AI research**:
 - Engineering
 - solving of hard problems
 - Cognitive
 - Understanding the nature of human intelligence

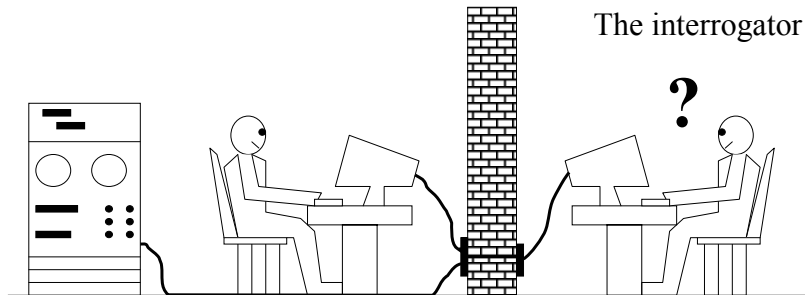
Intelligence and machines

- **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?

Eliza program

- **Eliza, the 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>

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.

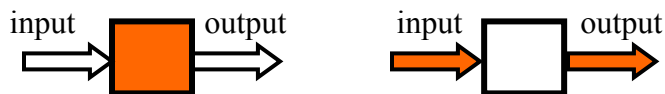
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Try it yourself at: <http://www-ai.ijs.si/eliza/eliza.html>

What is Artificial Intelligence ?

Four different views on what makes an AI system!! Depends on what matters more in the evaluation.

- **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)

Some AI definitions

	Human	Rational
Think	<p>“The exciting new effort to make computers think ... <i>machines with minds</i>, in the full and literal sense” (Haugeland, 1985)</p> <p>“[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning ...” (Bellman, 1978)</p>	<p>“The study of mental faculties through the use of computational models” (Charniak and McDermott, 1985)</p> <p>“The study of the computations that make it possible to perceive, reason, and act” (Winston, 1992)</p>
Act	<p>“The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990)</p> <p>“The study of how to make computers do things at which, at the moment, people are better” (Rich and Knight, 1991)</p>	<p>“A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes” (Schalkoff, 1990)</p> <p>“The branch of computer science that is concerned with the automation of intelligent behavior” (Luger and Stubblefield, 1993)</p>

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Rational agents

- The textbook we use adopts the rational agent perspective
 - **How to design a rational agent?**
- **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
- **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.

Two sources motivating 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.

Before AI. 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). Fraud: a chess player hidden inside the machine.
- **Robots.** Drama R.U.R. by K. Capek (early 20th century)

Before AI. Models of reasoning.

- Philosophers and mathematicians worked on models of reasoning and thought.

Timeline:

- **Aristotle** (384-322 B.C), ancient Greece, philosopher
 - Tried to explain and codify certain types of deductive reasoning, that 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).
 - Boolean model of a human brain.
- **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 and recognition**
 - Build on McCulloch and Pitts' work (1943)
 - **Objective:** replicate self-organization and subsequently phenomenon intelligence
 - **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)

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.

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 (where are we?)

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

Recent theoretical advances and solutions:

- Methods for dealing with uncertainty
- Planning
- Learning
- Optimizations

Applications:

- Focus on partial intelligence (not all human capabilities)
- Systems with components of intelligence in a specific application area; not general multi-purpose intelligent systems

AI applications: Software systems.

Diagnosis of software, technical components

Adaptive systems

- Adapt to the user
- **Examples:**
 - **Intelligent interfaces**
(<http://www.research.microsoft.com/research/dtg/>)
 - **Intelligent helper applications**, intelligent tutoring systems
 - **Web agents:**
 - crawlers
 - softbots, shopbots (see e.g. <http://www.botspot.com/>)

AI applications: Speech recognition.

- **Speech recognition systems:**
 - Hidden Markov models
- **Adaptive speech systems**
 - Adapt to the user (training)
 - continuous speech
 - commercially available software (e.g. IBM <http://www-3.ibm.com/software/speech/>)
- **Multi-user speech recognition systems**
 - Restricted (no training)
 - Used often in the customer support
 - Airline schedules, baggage tracking;
 - Credit card companies.

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Applications: Space exploration

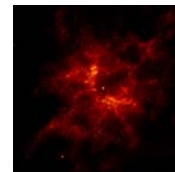
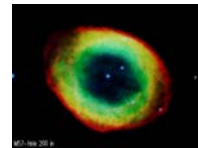
Autonomous rovers,
intelligent probes



Telescope scheduling



Analysis of data

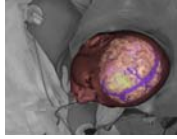
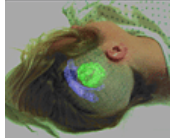


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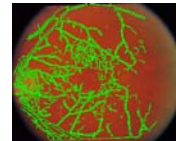
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AI applications: Medicine.

- **Medical diagnosis:**
 - Pathfinder. Lymph-node pathology.
 - QMR system. Internal medicine.
- **Medical imaging**
 - <http://www.ai.mit.edu/projects/medical-vision/>
 - Image guided surgery (Eric Grimson, MIT)



- Image analysis and enhancement

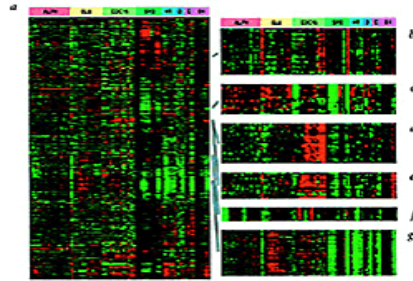
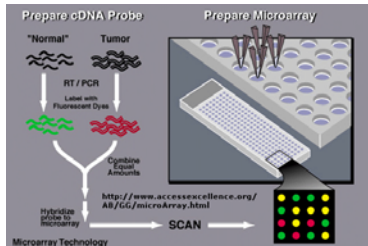


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AI applications: Bioinformatics.

- **Genomics and Proteomics**
 - Sequence analysis
 - Prediction of gene regions on DNA
 - Analysis of 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) .
 - Autonomous vehicle
 - Driving across US
- DARPA challenge (<http://www.darpa.mil/grandchallenge/>)
 - Drive across Mojave desert (route went from California to Nevada)



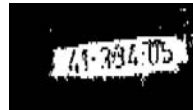
Sandstorm -- winner from CMU, but none of the contestants was able to finish the route



- This year challenge is in October
 - 43 entries

AI applications: Transportation.

- **Vision systems:**
 - Automatic plate recognition

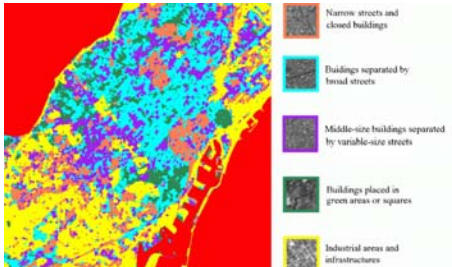


- Pedestrian detection
(Daimler-Benz)



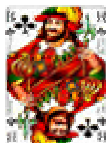
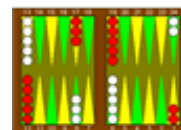
- Traffic monitoring
- **Route optimizations**

Classification of images or its parts



AI applications: Game playing.

- **Backgammon**
 - TD-backgammon
 - a program that learned to play at the championship level (from scratch).
 - reinforcement learning
- **Chess**
 - Deep blue (IBM) program beats Kasparov.
- **Bridge**
- **Etc.**



AI applications.

- **Robotic toys**

- Sony's Aibo

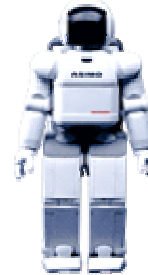
- [\(http://www.us.aibo.com/\)](http://www.us.aibo.com/)



- **Humanoid robot**

- Honda's ASIMO

- [\(http://world.honda.com/robot/\)](http://world.honda.com/robot/)



Other application areas

- **Text classification, document sorting:**

- Web pages, e-mails

- Articles in the news

- **Video, image classification**

- **Music composition, picture drawing**

- **Entertainment ☺**



Topics to be covered in the course

Five main areas:

- **Problem solving and search.**
 - Formulating a search problem, Uninformed and Informed Search, Constraint Satisfaction Search, Combinatorial and Parametric Optimization.
- **Logic and knowledge representations.**
 - Propositional and First-order logic, Inference.
- **Planning.**
 - Situation calculus, STRIPS, Partial-order planners, GraphPlan and SAT planners.
- **Uncertainty.**
 - Modeling uncertainty, Bayesian belief networks, Inference in BBNs, Decision making in the presence of uncertainty.
- **Learning.**
 - Logistic and linear regression, Neural networks, Density estimation, Learning of BBNs.