

# CS 2710 Foundations of AI Lecture 1

## Course overview

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## Course administrivia

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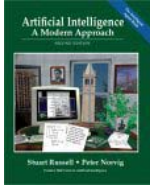
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**Course web page:**

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

## Textbook

### Course textbook:



Stuart Russell, Peter Norvig.

*Artificial Intelligence: A modern approach.*

2<sup>nd</sup> edition, Prentice Hall, 2002

### Other widely used AI textbooks:

Dean, Allen, Aloimonos: Artificial Intelligence.

P. Winston: Artificial Intelligence, 3<sup>rd</sup> ed.

N. Nilsson: Principles of AI.

## Grading

- Lectures 10%
- Homeworks 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

## Homeworks

- **Homeworks:**
  - 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

## 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

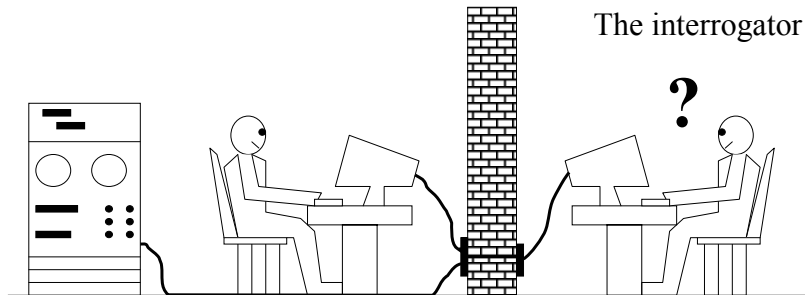
## Intelligence and machines

- **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.

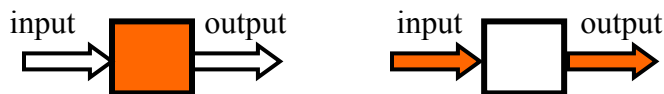
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Try it yourself at: <http://www-ai.ijs.si/eliza/eliza.html>

## 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
<b>Think</b>	<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>
<b>Act</b>	<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
 
$$f : \text{Percepts} \rightarrow \text{Actions}$$
- **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 20<sup>th</sup> 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 20<sup>th</sup> 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

- High expectations in very short time
- Computational complexity: some problems are intrinsically hard
- 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.

## Applications: Space exploration

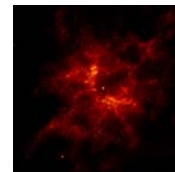
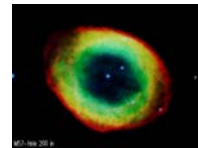
Autonomous rovers,  
intelligent probes



Telescope scheduling

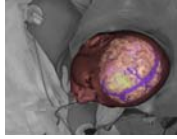
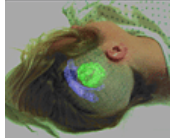


Analysis of data

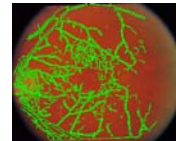


## AI applications: Medicine.

- **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

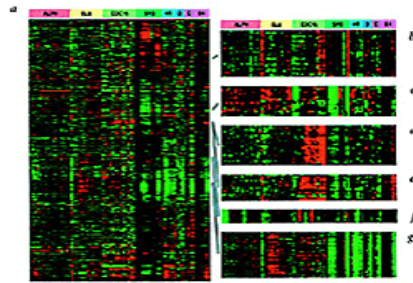
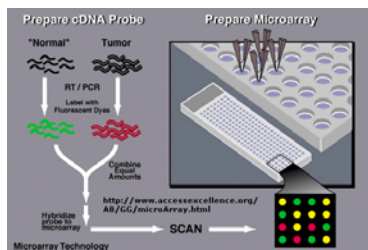


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## AI applications: Bioinformatics.

- **Genomics**
  - Gene sequencing
  - Prediction of gene regions on DNA
  - Micro-array data analysis: find genes 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:
  - Drive across Mojave desert (route went from California to Nevada)



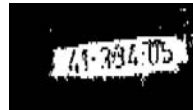
Sandstorm -- winner from CMU, but none of the contestants was able to finish the route



Caltech's entry

## AI applications: Transportation.

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

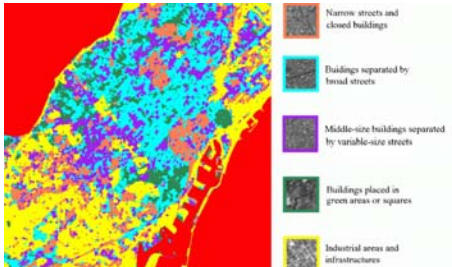


- Pedestrian detection  
(Daimler-Benz)



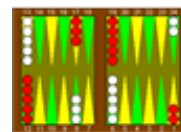
- Traffic monitoring
- **Route optimizations**

## 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

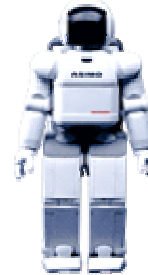
- (<http://www.us.aibo.com/>)



- **Humanoid robot**

- Honda's ASIMO

- (<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.