Course overview

Milos Hauskrecht
milos@cs.pitt.edu
5329 Sennott Square

Course administrivia

Instructor: Milos Hauskrecht
5329 Sennott Square
milos@cs.pitt.edu

TA: Tomas Singliar
5406 Sennott Square
tomas@cs.pitt.edu

Course web page:
http://www.cs.pitt.edu/~milos/courses/cs2710/
Textbook

Course textbook:
Stuart Russell, Peter Norvig.
Artificial Intelligence: A modern approach.

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](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 is 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](http://www-ai.ijs.si/eliza/eliza.html)

- **Info:**
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

What is Artificial Intelligence?

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

• **Reasoning vs. Behavior**

  ![Diagram](https://via.placeholder.com/150)

  – 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

<table>
<thead>
<tr>
<th>Think</th>
<th>Human</th>
<th>Rational</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The exciting new effort to make computers think … machines with minds, in the full and literal sense” (Haugeland, 1985)</td>
<td>“The study of mental faculties through the use of computational models” (Charniak and McDermott, 1985)</td>
<td></td>
</tr>
<tr>
<td>“[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning …” (Bellman, 1978)</td>
<td>“The study of the computations that make it possible to perceive, reason, and act” (Winston, 1992)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Act</th>
<th>Human</th>
<th>Rational</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990)</td>
<td>“A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes” (Schalkoff, 1990)</td>
<td></td>
</tr>
<tr>
<td>“The study of how to make computers do things at which, at the moment, people are better” (Rich and Knight, 1991)</td>
<td>“The branch of computer science that is concerned with the automation of intelligent behavior” (Luger and Stubblefield, 1993)</td>
<td></td>
</tr>
</tbody>
</table>

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 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 elicitin 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**  
- **Intelligent helper applications**, intelligent tutoring systems
- **Web agents:**
  - crawlers
  - softbots, shopbots (see e.g. [http://www.botspot.com/](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/](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

<table>
<thead>
<tr>
<th>Autonomous rovers, intelligent probes</th>
<th>Telescope scheduling</th>
<th>Analysis of data</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Autonomous rovers" /></td>
<td><img src="image2.png" alt="Telescope scheduling" /></td>
<td><img src="image3.png" alt="Analysis of data" /></td>
</tr>
</tbody>
</table>
AI applications: Medicine.

- **Medical diagnosis:**
  - Pathfinder. Lymph-node pathology.
  - QMR system. Internal medicine.

- **Medical imaging**
  [Link](http://www.ai.mit.edu/projects/medical-vision/)
  - Image guided surgery (Eric Grimson, MIT)
  - Image analysis and enhancement

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.
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)
    - This year challenge is in October
    - 43 entries

**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.