CS 1571 Introduction to AI
Lecture 1

Course overview

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Course administrivia

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Course web page:
http://www.cs.pitt.edu/~milos/courses/cs1571/
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. Nillson: Principles of AI.

Grading

- Lectures 15%
- Homework assignments 40%
- Midterm 20%
- Final 25%
Lectures

- 15% 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:
  - 40% 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:
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?

**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](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**
  - 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>
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<tr>
<th>Human</th>
<th>Rational</th>
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<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>
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<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>
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<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>
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<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>
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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
    \[ f : Percepts \rightarrow Actions \]

- **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).
• 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 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 patterns and pattern 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

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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 applications:**
  - softbots, shopbots (see e.g. [http://www.botspot.com/](http://www.botspot.com/) )
AI applications: information retrieval.

- **Web search engines**
  - Improve the quality of search
  - Rely on methods developed in AI
  - Add inferences

- **Web agents:**
  - softbots, shopbots (see e.g. [http://www.botspot.com/](http://www.botspot.com/))

- **Semantic web (or web 2):**
  - From information to knowledge sharing
  - Ontology languages

AI applications: Speech recognition.

- **Speech recognition systems:**
  - Early systems based on the Hidden Markov models
- **Adaptive speech systems**
  - Adapt to the user (training)
  - continuous speech
  - commercially available software – (Nuance, IBM)
- **Multi-user speech recognition systems**
  - Restricted (no training)
  - Voice command/voice activated devices
  - Customer support systems:
    - Airline schedules, baggage tracking;
    - Credit card companies
Applications: Space exploration

- Autonomous rovers, intelligent probes
- Analysis of data
- Telescope scheduling

AI applications: Medicine.

- Medical diagnosis: QMR system. Internal medicine.
- Patient Monitoring and Alerting: Cerner
- Medical imaging
  - http://groups.csail.mit.edu/vision/medical-vision/index.html
  - Image guided surgery
  - Classification of body structures and visualization
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

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
  - 2004 – no vehicle finished the course
  - 2005 – 5 vehicles finished
    - Stanford team won
  - 2007 - DARPA Urban Challenge
    - 60 miles in urban area settings
    - 6 vehicles finished, CMU won
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, Poker**

- **IBM’s Watson project**
  - A program to compete in Jeopardy competition

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AI applications

- **Robotic toys**
  - Sony’s Aibo

- **Roomba vacuum cleaners**

- **Humanoid robot**
  - Honda’s ASIMO
Other application areas

- **Text classification, document sorting:**
  - Web pages, e-mails,
  - SPAM detection
  - Articles in the news
- **Video, image classification**
- **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