Artificial Intelligence

- **Instructor:** Prof. Dr. Brahim Hnich; h nich.brahim@gmail.com
- **TAs:** ??
- **Lectures:** Mondays 6:30—9:20 PM??
- **Office hours:** ??

- **Course web page:** [http://homes.ieu.edu.tr/~bhnich/](http://homes.ieu.edu.tr/~bhnich/)
  - Up to date information
  - Lecture notes
    - Based on Prof. L. Itti’s lecture notes
  - Relevant dates, links, etc.

- **Course material:**
Artificial Intelligence

- **Course overview:** foundations of symbolic intelligent systems. Agents, search, problem solving, logic, representation, reasoning, symbolic programming, etc.

- **Prerequisites:** Programming principles, discrete mathematics for computing, software design and software engineering concepts. Good knowledge of some programming language required for programming assignments.

- **Grading:** 30% for midterm + 40% for final + 30% for mandatory homeworks/assignments
Why study AI?

- Search engines
- Science
- Medicine/Diagnosis
- Labor
- Appliances
- What else?
Honda Humanoid Robot

Walk

Turn

http://world.honda.com/robot/

Stairs
Sony AIBO

http://www.aibo.com
Natural Language Question Answering

Robot Teams

USC robotics Lab
DARPA grand challenge

• Race of autonomous vehicles across California desert

• Vehicles are given a route as series of GPS waypoints

• But they must intelligently avoid obstacles and stay on the road

• About 130 miles of dirt roads, off-road, normal roads, bridges, tunnels, etc

• Must complete in less than 10 hours
AUVSI autonomous submarine competition

- Students build fully autonomous submarines

- Submarines must pass through a gate, locate bins, drop markers into the bins, locate and read barcodes under water, knock off blinking lights, etc

- Humans cannot interact with the robots at any time during the mission, GPS does not work underwater, visibility is very poor
What is AI?

The exciting new effort to make computers think ... *machine with minds*, in the full and literal sense” (Haugeland 1985)

“The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990)

“The study of mental faculties through the use of computational models” (Charniak et al. 1985)

A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes” (Schalkol, 1990)

Systems that think like humans
Systems that act like humans
Systems that think rationally
Systems that act rationally
Acting Humanly: The Turing Test

- Alan Turing's 1950 article *Computing Machinery and Intelligence* discussed conditions for considering a machine to be intelligent.

- "Can machines think?" $\leftrightarrow$ "Can machines behave intelligently?"
- The Turing test (The Imitation Game): Operational definition of intelligence.
Acting Humanly: The Turing Test

- Computer needs to possess: Natural language processing, Knowledge representation, Automated reasoning, and Machine learning

- Are there any problems/limitations to the Turing Test?
What tasks require AI?

• “AI is the science and engineering of making intelligent machines which can perform tasks that require intelligence when performed by humans ...”

• What tasks require AI?
What tasks require AI?

- Tasks that require AI:
  - Solving a differential equation
  - Brain surgery
  - Inventing stuff
  - Playing Jeopardy
  - Playing Wheel of Fortune
  - What about walking?
  - What about grabbing stuff?
  - What about pulling your hand away from fire?
  - What about watching TV?
  - What about day dreaming?
Acting Humanly: The Full Turing Test

- Alan Turing's 1950 article *Computing Machinery and Intelligence* discussed conditions for considering a machine to be intelligent
  - “Can machines think?” $\iff$ “Can machines behave intelligently?”
  - The Turing test (The Imitation Game): Operational definition of intelligence.

- Computer needs to posses: Natural language processing, Knowledge representation, Automated reasoning, and Machine learning

- Full Turing Test: Requires physical interaction and needs perception and actuation.
Acting Humanly: The Full Turing Test

Problem:
1) Turing test is not reproducible, constructive, and amenable to mathematic analysis.
2) What about physical interaction with interrogator and environment?

Trap door
What would a computer need to pass the Turing test?

- **Natural language processing**: to communicate with examiner.
- **Knowledge representation**: to store and retrieve information provided before or during interrogation.
- **Automated reasoning**: to use the stored information to answer questions and to draw new conclusions.
- **Machine learning**: to adapt to new circumstances and to detect and extrapolate patterns.
What would a computer need to pass the Turing test?

- **Vision** (for Total Turing test): to recognize the examiner’s actions and various objects presented by the examiner.

- **Motor control** (total test): to act upon objects as requested.

- **Other senses** (total test): such as audition, smell, touch, etc.
Thinking Humanly: Cognitive Science

• 1960 “Cognitive Revolution”: information-processing psychology replaced behaviorism

• Cognitive science brings together theories and experimental evidence to model internal activities of the brain
  • What level of abstraction? “Knowledge” or “Circuits”?  
  • How to validate models?  
    • Predicting and testing behavior of human subjects (top-down)  
    • Direct identification from neurological data (bottom-up)  
    • Building computer/machine simulated models and reproduce results (simulation)
Thinking Rationally: Laws of Thought

• Aristotle (~ 450 B.C.) attempted to codify “right thinking”
  What are correct arguments/thought processes?

• E.g., “Socrates is a man, all men are mortal; therefore Socrates is mortal”

• Several Greek schools developed various forms of logic: notation plus rules of derivation for thoughts.
Thinking Rationally: Laws of Thought

• **Problems:**
  1) Uncertainty: Not all facts are certain (e.g., *the flight might be delayed*).

  2) Resource limitations:
    - Not enough time to compute/process
    - Insufficient memory/disk/etc
    - Etc.
Acting Rationally: The Rational Agent

• Rational behavior: Doing the right thing!

• The right thing: That which is expected to maximize the expected return

• Provides the most general view of AI because it includes:
  • Correct inference ("Laws of thought")
  • Uncertainty handling
  • Resource limitation considerations (e.g., reflex vs. deliberation)
  • Cognitive skills (NLP, AR, knowledge representation, ML, etc.)

• **Advantages:**
  1) More general
  2) Its goal of rationality is well defined
How to achieve AI?

• How is AI research done?

• AI research has both theoretical and experimental sides. The experimental side has both basic and applied aspects.

• There are two main lines of research:
  • One is biological, based on the idea that since humans are intelligent, AI should study humans and imitate their psychology or physiology.
  • The other is phenomenal, based on studying and formalizing common sense facts about the world and the problems that the world presents to the achievement of goals.

• The two approaches interact to some extent, and both should eventually succeed. It is a race, but both racers seem to be walking. [John McCarthy]
Branches of AI

- Logical AI
- Search
- Natural language processing
- Pattern recognition
- Knowledge representation
- Inference From some facts, others can be inferred.
- Automated reasoning
- Learning from experience
- Planning To generate a strategy for achieving some goal
- Epistemology Study of the kinds of knowledge that are required for solving problems in the world.
- Ontology Study of the kinds of things that exist. In AI, the programs and sentences deal with various kinds of objects, and we study what these kinds are and what their basic properties are.
- Genetic programming
- Emotions???
- ...

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## AI Prehistory

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AI History

1943  McCulloch & Pitts: Boolean circuit model of brain
1950  Turing's "Computing Machinery and Intelligence"
1952–69 Look, Ma, no hands!
1950s  Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
1956  Dartmouth meeting: "Artificial Intelligence" adopted
1965  Robinson's complete algorithm for logical reasoning
1966–74 AI discovers computational complexity
       Neural network research almost disappears
1969–79 Early development of knowledge-based systems
1980–88 Expert systems industry booms
1988–93 Expert systems industry busts: "AI Winter"
1985–95 Neural networks return to popularity
1988– Resurgence of probabilistic and decision-theoretic methods
       Rapid increase in technical depth of mainstream AI
       "Nouvelle AI": ALife, GAs, soft computing
AI State of the art

• Have the following been achieved by AI?
  • World-class chess playing
  • Playing table tennis
  • Cross-country driving
  • Solving mathematical problems
  • Discover and prove mathematical theories
  • Engage in a meaningful conversation
  • Understand spoken language
  • Observe and understand human emotions
  • Express emotions
  • ...

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Course Overview

**General Introduction**


Course Overview (cont.)

How can we solve complex problems?


Using these 3 buckets, measure 7 liters of water.

Traveling salesperson problem
Course Overview (cont.)

Practical applications of search.


![Tic-tac-toe diagram]
Course Overview (cont.)

Towards intelligent agents


Course Overview (cont.)

**Building knowledge-based agents: 1st Order Logic**


Course Overview (cont.)

**Representing and Organizing Knowledge**


An ontology for the sports domain
Course Overview (cont.)

**Reasoning Logically**


![Diagram of backward chaining example](image)
Course Overview (cont.)

Examples of Logical Reasoning Systems

- **19-Logical reasoning systems.**

Semantic network used in an insight generator (Duke university)
Course Overview (cont.)

Systems that can Plan Future Behavior

Course Overview (cont.)

What challenges remain?

- **Overview and summary.** [all of the above] What have we learned. Where do we go from here?
Outlook

• AI is a very exciting area right now.

• This course will teach you the foundations.