# CISC 3410
# Artificial Intelligence

## Chapter 1: Introduction

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# Definition of AI

| Thinking Humanly | Thinking Rationally |
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| "The exciting new effort to make computers think . . . *machines with minds,* in the full and literal sense." (Haugeland, 1985)<br><br>"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning .. ." (Hellman, 1978) | "The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)<br><br>"The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992) |
| **Acting Humanly** | **Acting Rationally** |
| "The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)<br><br>"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991) | "Computational Intelligence is the study of the design of intelligent agents." (Poole *et at,* 1998)<br><br>"Al . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998) |

# Acting Humanly

- **The Turing Test**
  - A computer passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses come from a person or from a computer.
    - **natural language processing**
    - **knowledge representation**
    - **automated reasoning**
    - **machine learning**
- **Total Turing Test**
    - **computer vision**
    - **robotics**

## Thinking Humanly: Cognitive Modelling

- We need to get *inside* the actual workings of human minds
  - through introspection
  - through psychological experiments
  - through brain imaging
- **Cognitive Science**
  - Interdisiplinary field (AI, psychology,linguistics, philosophy, anthropology) that tries to form computational theories of human cognition.

## Thinking Rationally: Laws of Thought

- Formalize “correct” reasoning using a mathematical model (e.g. of deductive reasoning)
- Encode knowledge in formal logical statements and use mathematical deduction to perform reasoning
  - Problems:
    - Formalizing common sense knowledge is difficult
    - General deductive inference is computationally intractable.

## Acting Rationally: Rational Agents

- A rational agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.
  - An agent is an entity that perceives its environment and is able to execute actions to change it.
  - Agents have inherent goals that they want to achieve.
  - Limited rationality involves maximizing goals within the computational and other resources available.

- **Philosophy**
  - Can formal rules be used to draw valid conclusions?
  - How does the mind arise from a physical brain?
  - Where does knowledge come from?
  - How does knowledge lead to action?
- **Mathematics**
  - What are the formal rules to draw valid conclusions?
  - What can be computed?
  - How do we reason with uncertain information?

- **Economics**
  - How should we make decisions so as to maximize payoff?
  - How should we do this when others may not go along?
  - How should we do this when the payoff may be far in the future?
- **Neuroscience**
  - How do brains process information?
- **Psychology**
  - How do humans and animals think and act?

- **Computer engineering**
  - How can we build an efficient computer?
- **Control theory and cybernetics**
  - How can artifacts operate under their own control?
- **Linguistics**
  - How does language relate to thought?

## The birth of artificial intelligence

- McCullouch and Pitts (1943) theory of neurons as logical computing circuits.
- Work in early 50's by Claude Shannon and Turing on game playing and Marvin Minsky on neural networks.
- Dartmouth conference (1956)
  - Organized by John McCarthy attended by Marvin Minsky, Allen Newell, Herb Simon, and a few others.
  - Coined term "artificial intelligence."
  - Presentation of game playing programs and Logic Theorist.

# Early Years

- Development of General Problem Solver by Newell and Simon in early sixties.
- Arthur Samuel's late fifties work on learning to play checkers.
- Frank Rosenblatt's Perceptron (1962) for training simple neural networks
- Development of LISP symbolic programming language
- J.A. Robinson's resolution method (1965)

# Early Years (Cont.)

- Work in the sixties at MIT lead by Marvin Minsky and John McCarthy
  - SAINT: Solved freshman calculus problems
  - ANALOGY: Solved IQ test analogy problems
  - SIR: Answered simple questions in English
  - STUDENT: Solved algebra story problems
  - SHRDLU: Obeyed simple English commands in the blocks world

- Hard to scale solutions from toy problems to more realistic ones
  - Most early programs knew nothing of their subject matter. They succeeded by means of simple syntactic manipulations.
  - Many of the problems that Al was attempting to solve are intractable.
  - Limitations of Perceptron demonstrated by Minsky and Papert (1969).

# Knowledge is Power: Expert Systems

- Discovery that detailed knowledge of the specific domain can help control search and lead to expert level performance for restricted tasks.
- First expert system DENDRAL for interpreting mass spectrogram data to determine molecular structure by Buchanan, Feigenbaum, and Lederberg (1969).
- Early expert systems developed for other tasks
  - MYCIN: diagnosis of bacterial infection (1975)
  - PROSPECTOR: Found molybendum deposit based on geological data (1979)
  - R1: Configure computers for DEC (1982)

# AI Industry

- Development of numerous expert systems in early eighties.
- Japanese start “Fifth Generation” project in 1981 to build intelligent computers based on Prolog logic programming.
- MCC established in Austin in 1984 to counter Japanese project.
- Limitations become apparent, prediction of AI Winter
  - Brittleness and domain specificity
  - Knowledge acquisition bottleneck

## The return of neural networks

- New algorithms, such as back-propagation, discovered for training more complex neural networks (1986).
- Connectionist models vs. symbolic models
- Neural network research
  - create effective network architectures and algorithms and understanding their mathematical properties
  - careful modeling of the empirical properties of actual neurons and ensembles of neurons
- Industrial applications (e.g., OCR)

## *Recent Trends*

- General focus on learning and training methods to address knowledge-acquisition bottleneck.
- Shift of focus from rule-based and logical methods to probabilistic and statistical methods (e.g. Bayes nets, Hidden Markov Models, Data mining).
- Increased interest in particular tasks and applications
  - Intelligent agents and Internet applications
  - Self-driving cars
  - recognition, machine translation, language understanding
  - AI planning