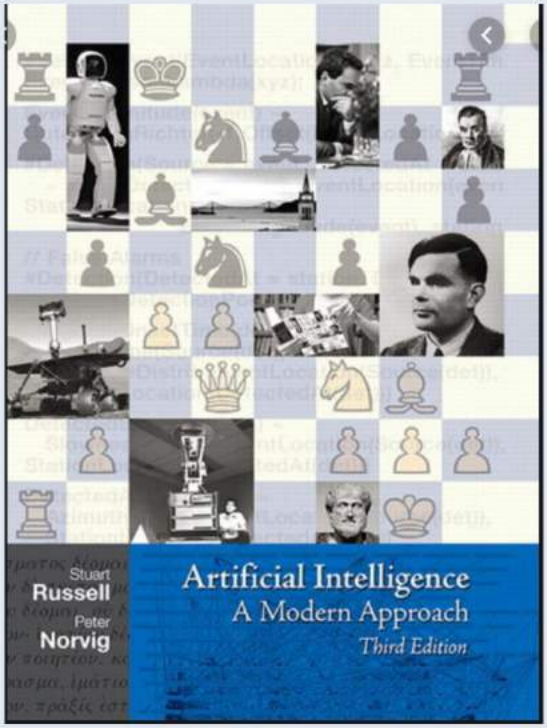
Introduction to Artificial Intelligence and Expert Systems

Dr. Nasima Begum
Associate Professor
Dept. of CSE, UAP

Text Book


Stuart
Russell
Peter
Norvig
Artificial Intelligence
A Modern Approach
Third Edition

Topics

- This course covers seven major topics
  - Search (Chapter 3, 5, 6)
  - Knowledge Representation and Inference (Chapter 8, 9)
  - Fuzzy Logic
  - ANN
  - Genetic Algorithm
  - Machine Learning
  - Probabilistic Reasoning and Uncertainty

Grading

- Final 50%
  - 30% Lessons from the Mid will be asked in the final.
- Mid 20%
  - No missed make up will be arranged
- Class Test 20%
  - Best 3 will be counted out of 4/5
- Assignment 10%
  - 3 assignment will be given, you will receive zero after the deadline
- Attendance (not bellow 70%)
  - UAP policy will be followed strictly

Course Overview

- Introduction
- Intelligent Agent
- Searching in AI
  - Uninformed, informed, etc.
- Knowledge Representation
  - Fuzzy Logic, FOPL, Semantic Nets, Frames, Predicate Logic
- Reasoning and Inference
  - Semantic Nets, Frames, Predicate Logic
- Reasoning with Uncertainty
  - Probability, Bayesian Decision Making, etc.
- PROLOG
  - Variables, Functions, Expressions, Constraints
- Genetic Algorithm (GA)
  - Selection, Cross-over, Mutation
- Fuzzy Expert System
  - Fuzzy sets, Linguistic Variables, Hedges, Fuzzy Inference
- Artificial Neural Network
  - Perceptron, Back-propagation
- Expert systems
- NLP
  - Variables, Functions, Expressions, Statements

History of AI

The birth of AI (1943-1956)

- McCulloch and Pitts, *A logical Calculus of Ideas Immanent in Nervous Activity,* 1943
- Turing, *Computing Machinery and Intelligence*, 1950
- Shannon, *Programming a Computer for Playing Chess*, 1950
- The Dartmouth College Workshop on Machine Intelligence, 1956

The rise of AI (1956-1969)

- LISP McCarthy, 1956
- GPS Newell and Simon 1972
- Minsky, *A framework for representing knowledge*, 1975

The discovery of Expert systems (1970 – 1985)

- DENDRAL - First knowledge based expert system supported by NASA to determine the molecular structure of Mars soil. (Buchanan - 1969)
- MYCIN - to diagnose infectious blood disease. (1976)
- PROSPECTOR for mineral exploration developed by Stanford University, (1979).
- PROLOG – a Logic Programming Language (Colmerauer, Roussel and Kowalski, France

The rebirth of AI (1985 - onwards)

- Hopfield, Neural Networks
- Kohonen, Self-organized Formation of Topologically correct Feature Maps
- Rumelhart Parallel Distributed Processing
- Fuzzy Logic by Lotfi Zadeh, GA by Rechenberg, …...

What is AI?

Are these Intelligent?

What is AI?

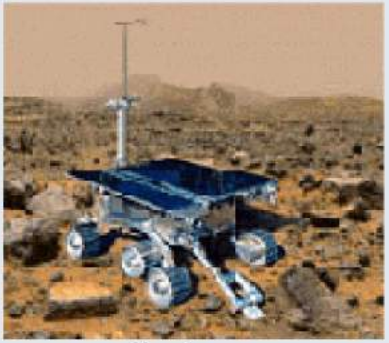
What about these?

What is Intelligence?

- Intelligence is **the ability to understand and learn things.** -> Essential English Dictionary
- "Intelligence is **the capacity to act purposefully** with the environment" -> David Weshlar (American Physiologist)
- "Intelligence is the **general mental adaptability** to new problems and conditions" -> W. Stern (German psychologist)
- The **capacity to acquire and apply knowledge**.
- Learning? - Any relatively permanent change in behavior which occurs as a result of experience or practice.

Why Study AI?

Automated Car



Science

Google

YAHOO!

Search engines

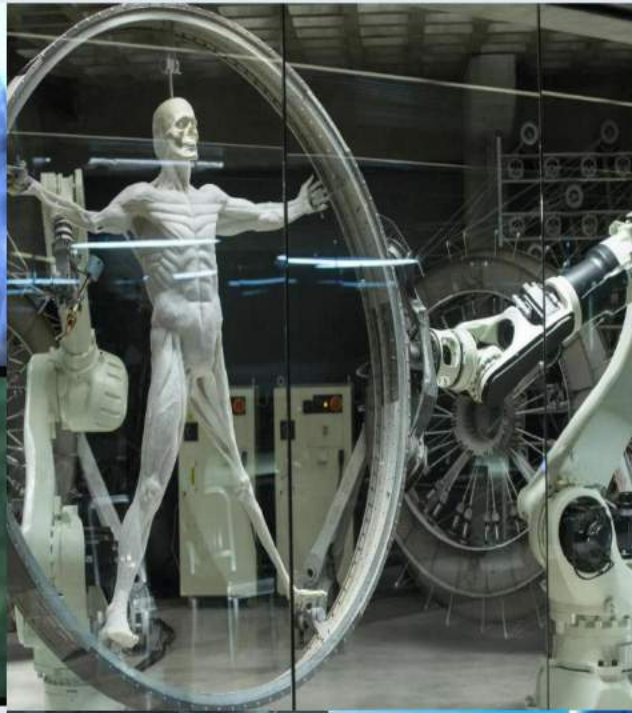
Labor

Appliances

Medicine/
Diagnosis

What else?

Sci-Fi AI



What is AI?

- "AI is a branch of computer science by which we can create intelligent machines which can **behave like a human**, **think like humans,** and **able to make decisions**."

- *Homo sapiens*—Latin, literally 'wise man'.
- ***how we think,* perceive, understand, predict, and manipulate**.

- It attempts not just to understand but also to build intelligent entities

What is Artificial Intelligence?

- **AI is a branch of Computer Science concerned with the study and creation of computer systems that exhibit some form of intelligence.**

a) Learn new concepts

b) Reason and draw useful conclusions about the world

c) Understand a natural language or perceive and comprehend a visual scene

d) Perform other types of feats that require human types of intelligence

- **Goal of AI: make machines to do things that would require intelligence if done by humans.**

- Replicate human intelligence

- Solve Knowledge-intensive tasks

- Building a machine which can perform tasks that requires human intelligence such as: Driving a car in traffic

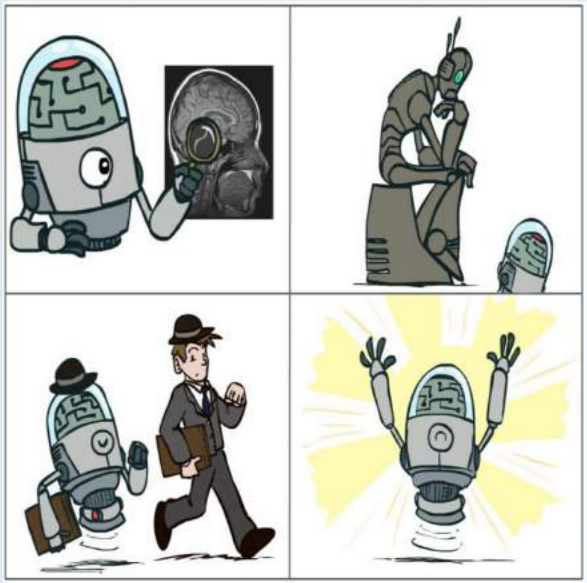
-Creating some system which can exhibit intelligent behavior, learn new things by itself, demonstrate, explain, and can advise to its user.

What is Artificial Intelligence?

- **AI is a discipline that systematizes and automates intellectual tasks to create machines to**

Act like humans	Act rationally
Think like humans	Think rationally

Think like people



Think rationally

Act like people

Act rationally

Act Like Humans

- The goal of AI is to create computer systems which perform functions that are assumed to require intelligence when done by humans.

→ Methodology:
Take a task at which people are better, e.g.:

- Prove a theorem
- Play chess
- Plan a surgical operation
- Diagnose a disease
- Navigate in a building

and make a computer do it

Think Like Humans

- How the computer performs functions does matter
- Comparison of the traces of the reasoning steps **(cognitive science)**
- **But, do we want to duplicate human imperfections?**
- Role of explicit symbolic knowledge (lemmas, concepts, …)
- Pattern recognition → Neural nets
- Still a research topic: from signals to symbols

Think/Act Rationally

- Always make the "best" decision given what is available (knowledge, time, resources)
- "best" → maximizes the **expected** value of a **utility function** (≠ perfection)
- Strong ties to economics (e.g., game theory), probabilistic modeling, and control theory
- But, to some extent, the role of consciousness, emotions, or fear of dying on intelligence is ignored.

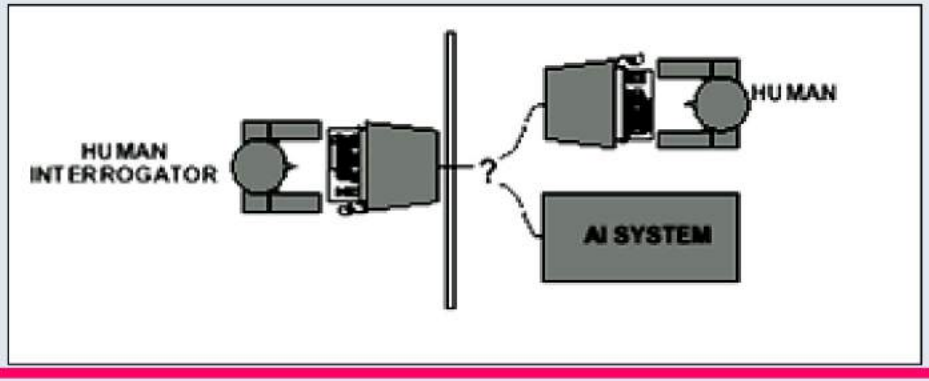
Intelligent Machine

- **Alan Turing's 1950 article *Computing Machinery and Intelligence* discussed conditions for considering a machine to be intelligent**
  - **"Can machines think?" ←→ "Can machines behave intelligently?"**
  - **The Turing Test (The Imitation Game): Operational definition of intelligence. Can a computer convince a human interrogator that it is a human?**

H interrogates X in a black box

If X is a computer, but H cannot tell, X must be intelligent!

Computer needs to posses: Natural language processing, Knowledge representation, Automated reasoning, and Machine learning. Are there any problems/limitations to the Turing Test?



Acting humanly: The Turing Test approach

- The **Turing Test**, proposed by Alan Turing (1950), was designed to provide a satisfactory operational definition of intelligence. 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.

1. **natural language processing** to enable it to communicate successfully in English
2. **knowledge representation** to store what it knows or hears
3. **automated reasoning** to use the stored information to answer questions and to draw new conclusions
4. **machine learning** to adapt to new circumstances and to detect and extrapolate patterns

Acting humanly: The Turing Test approach

- **Total Turing Test** includes a video signal so that the interrogator can test the subject's perceptual abilities, as well as the opportunity for the interrogator to pass physical objects "through the hatch."
- To pass the total Turing Test, the computer will need

5. **computer vision** to perceive objects, and
6. **robotics** to manipulate objects and move about

Acting rationally: The rational agent approach

- An **agent** is just something that acts purposefully
- Of course, all computer programs do something, but computer **agents** are expected to do more: operate autonomously, perceive their environment, persist over a prolonged time period, adapt to change, and create and pursue goals.
- A **rational agent** is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.

Acting rationally: The rational agent approach

- The rational-agent approach has two advantages over the other approaches.
- First, it is more general than the "laws of thought" approach because correct inference is just one of several possible mechanisms for achieving rationality. There is no provably correct thing to do, but still something must be done.
- Second, it is more amenable scientific development than are approaches based on human behavior or human thought. The standard of rationality is mathematically well defined and completely general, and can be "unpacked" to generate agent designs that provably achieve it.

Natural Language

- Speech technologies (e.g. Siri)
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems
- Language processing technologies
  - Question answering
  - Machine translation


"Il est impossible aux journalistes de rentrer dans les régions tibétaines"

Bruno Philip, correspondant du "Monde" en Chine, estime que les journalistes de l'AFP qui ont été expulsés de la province tibétaine du Qinghai "n'étaient pas dans l'illégalité".

Les faits Le dalaï-lama dénonce l'"enfer" imposé au Tibet depuis sa fuite, en 1959

Vidéo Anniversaire de la rébellion


"It is impossible for journalists to enter Tibetan areas"

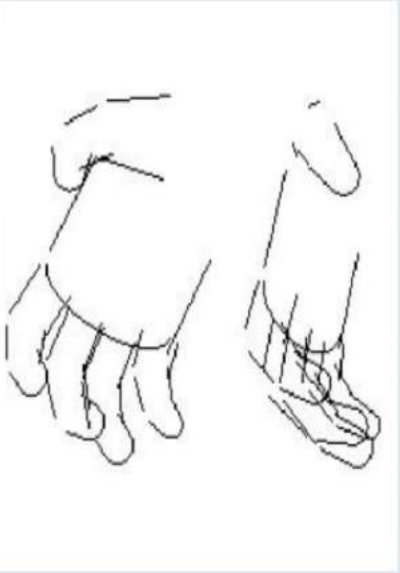
Philip Bruno, correspondent for "World" in China, said that journalists of the AFP who have been deported from the Tibetan province of Qinghai "were not illegal."

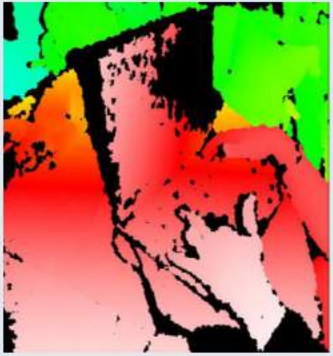
Facts The Dalai Lama denounces the "hell" imposed since he fled Tibet in 1959

Video Anniversary of the Tibetan rebellion: China on guard

Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification

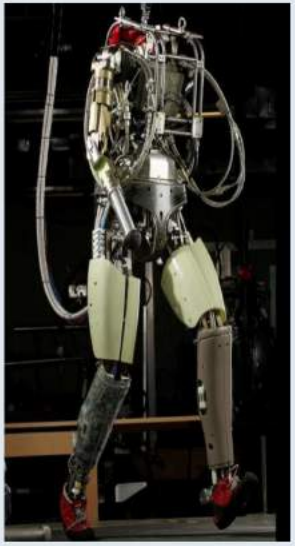




Images from Erik Sudderth (left), wikipedia (right)

Robotics

- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!
- Technologies
  - Vehicles
  - Rescue
  - Soccer!
  - Lots of automation…
- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control



Images from UC Berkeley, Boston Dynamics, RoboCup, Google

What is Knowledge?

(1) The fact or condition of knowing something with familiarity gained through experience or association

(2) Acquaintance with or understanding of a subject

- Facts and principles accumulated by human kind or the act, fact or state of knowing
- Familiarity of with language, concepts, procedures, rules, ideas, abstractions, customs, associations
- Coupled with an ability to use these notions effectively in modeling different aspects of the world
- Knowledge is the **perception about** and **understanding of a subject.**
- **Consists of facts, concepts, rules**

Rules as Knowledge Representation

- IF ‘traffic light’ is green
  THEN action is go

- IF ‘traffic light’ is red
  THEN action is stop

- IF car is dead
  AND ‘fuel tank’ is empty
  THEN action is ‘refuel the car’

Organization of Knowledge

- In biological organisms, knowledge is stored as complex structures of interconnected neurons.
- In computers, knowledge is stored as symbolic structures, but in the form of collections of magnetic spots and voltage states.
- Knowledge-based systems may require thousands of facts and rules to perform their intended tasks. So the appropriate facts and rules be easy to locate and retrieve. Knowledge can be organized in memory for easy access by a method known as indexing.
- Decisions in knowledge-based systems needs manipulation of knowledge in specified ways.

Importance of Knowledge

- Essential for intelligent behavior
- To perform a complex *robotic* task
- To develop a plan to complete a sequence of intricate operations

- Those who possess knowledge are called **experts**.

AI: Importance of Knowledge

Over the past few decades, several computer systems have been developed that can perform intelligence tasks such as diagnose diseases, understand human speech and so on. Artificial intelligence is the breakthrough of computer science explaining how it is possible for computers to reason and perceive.

It concerns with the study and creation of computer systems that exhibit magnificent form of intelligence. People enjoy this wonderful field because it provides a means of new ideas for representing knowledge and building expert systems. It provides an exciting computational perspective on the mystery of intelligence.

Examples of Knowledge

Rafi is tall: Expresses a simple fact, an attribute possessed by a person

Hasan loves Nila: A binary relation between two persons

- Mr. Peter suggested his students to learn E-commerce for the development of smart management system.

Different Kinds of Knowledge

- **Procedural**: Compiled knowledge related to the performance of some task
  - **knowing how to do something**
  - **Steps required to solve an algebraic equation**
- **Declarative**: Passive knowledge expressed as statements of facts about the world.
  - **knowing that something is true or false**
  - **Personal data in a database**
- **Heuristic**: For good judgments, or strategies, tricks, rules of thumb

Different Kinds of Knowledge

Heuristic Knowledge:

Knowledge is the acquirement of facts and information.

Knowledge can come from real-life experiences or theoretical education practices.

Heuristics are an aid to learning that allows us to experiment with what we have learned.

Data, Information and Knowledge

- **Data**: A symbolic representation of facts, measurements, or observations. Data is what we collect and store.
- Data *is the `raw material', the `mess of numbers'.*
- **Information**: Meaningful data
- **Knowledge**: A theoretical or practical understanding of a subject. Knowledge is what helps us to make appropriate decisions.
- Knowledge *is `condensed' information. It is a concise presentation of previous experience.*

Knowledge should not be confused with data!

More About Knowledge

- Belief: Any meaningful and coherent expression that can be represented.
- Hypothesis: A justified belief that is not known to be true.
- Knowledge: True justified belief
- Epistemology: The study of the nature of knowledge
- Meta Knowledge

Expert Systems

- Expert systems are knowledge-based systems which contain expert knowledge and can provide an expertise, similar to the one provided by an expert in a restricted application area.

- For example, an expert system for diagnosis of cars has a knowledge base containing rules for checking a car and finding faulty elements, as it would be done by a specialized engineer.

Knowledge in Expert Systems

Conventional Programming

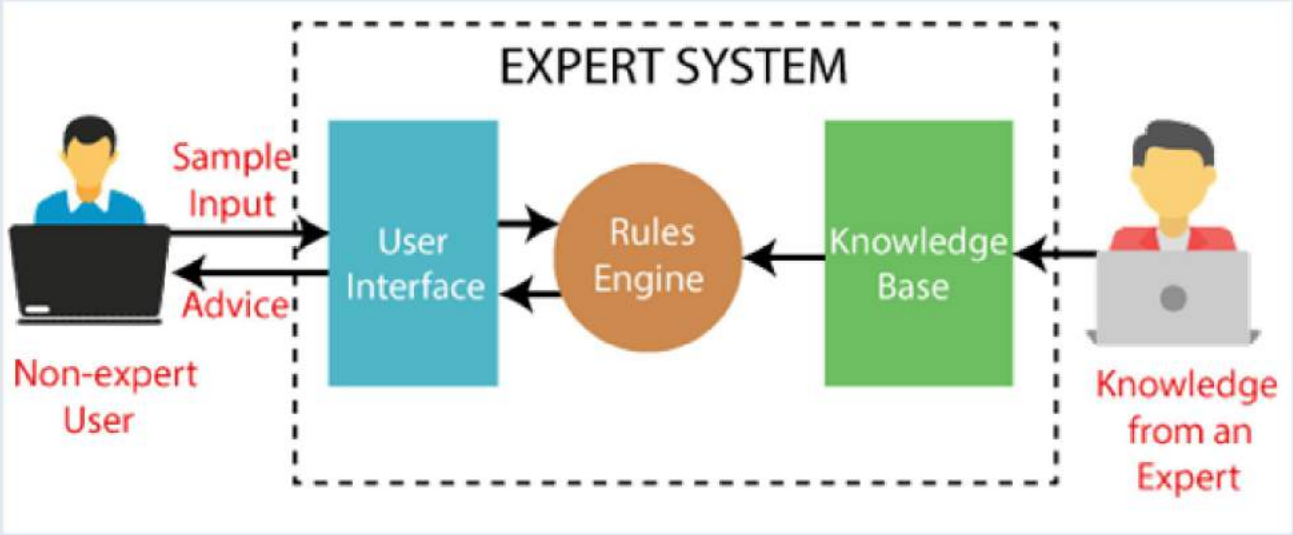
Algorithms
+ Data Structures
= Programs

Knowledge-Based Systems

Knowledge
+ Inference
= Expert System

Expert Systems .....

- An expert system consists of the following main blocks:
  - knowledge base (data base)
  - inference engine (explanation module)
  - user interface (knowledge acquisition module)



Examples of Expert Systems

- **Rule 1:**

IF (Score is high) and (Viva is good or GPA is excellent)

THEN (Decision is Selected)

Rule 2:

IF (Score is low) and (Viva is bad or GPA is marginal)

THEN (Decision is Disapprove)

Intelligent Machines

How does a human mind work?

Does a non human have mind?

Book References

- AIMA = Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norving (3rd / 4th Edition)
- Introduction to Artificial Intelligence and Expert Systems by Dan Patterson

Acknowledgement

- AIMA = Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norving (3rd edition)
- UC Berkeley
- U of toronto
- https://juniv.edu/teachers/shorifuddin
- Other online resources

Thank You