Artificial Intelligence (AI)

Prof Dr Mohammad Shorif Uddin

Department of Computer Science and Engineering

Jahangirnagar University

Savar, Dhaka, Bangladesh

https://www.juniv.edu/teachers/shorifuddin

Email: shorifuddin@juniv.edu

Tel: 01747615832

What's involved in Intelligence?

- Ability to interact with the world (speech, vision, motion, manipulation)
- Ability to model the world and to reason about it
- Ability to learn and to adapt

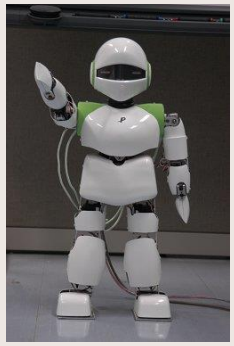
Goals in AI

- To build systems that exhibit intelligent behavior
- To understand intelligence in order to model it

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**
- **Learn new concepts**
- **Reason and draw useful conclusions about the world**
- **Understand a natural language or perceive and comprehend a visual scene**
- **Perform other types of feats that require human types of intelligence**

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



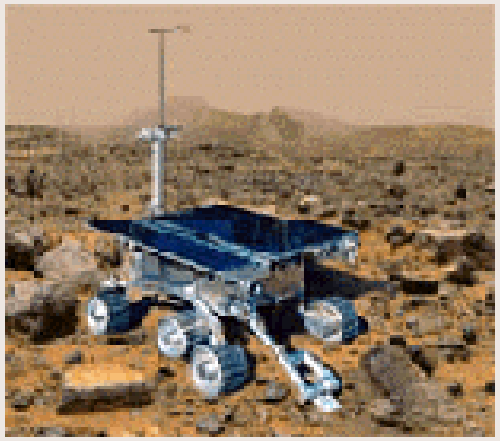
What is Artificial Intelligence?

AI is Discipline that systematizes and automates intellectual tasks to create machines to

Act like humans	Think like humans

Why study AI?

Labor



Science

Appliances

Google

YAHOO!

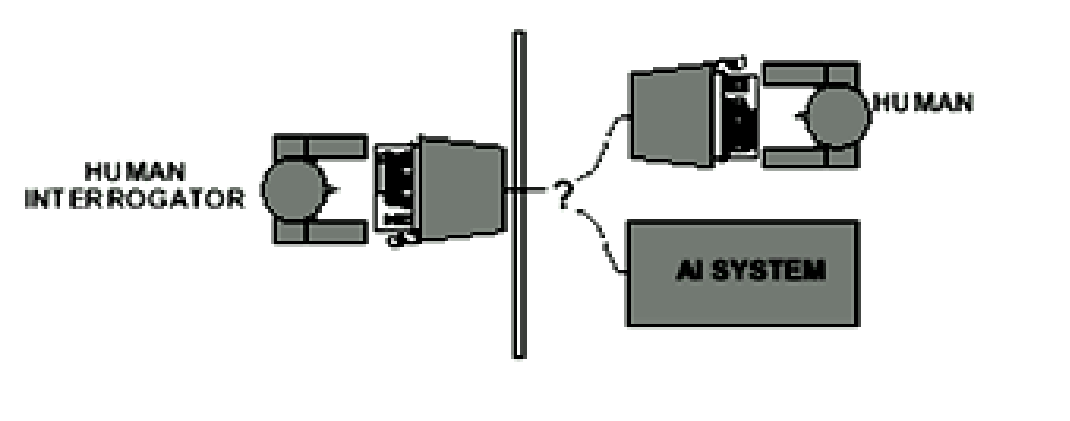
Search engines

Medicine/
Diagnosis

What else?

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



AI History

The Birth of AI (1943-1956)

- McCulloch and Pitts, A logical Calculus of Ideas Immanent in Nervous Activity, 1943 – Boolean Circuit Model of Brain.
- Turing, Computing Machinery and Intelligence, 1950
- Shannon, Programming a Computer for Playing Chess, 1950

The Rise of AI (1956-1969) and the Discovery of Expert Systems (1970– 1985); Expert Systems Industry booms

- The Dartmouth College Workshop on Machine Intelligence, 1956
- LISP Developed by McCarthy, 1958
- GA (Genetic Algorithm) by John Holland 1962
- Fuzzy Logic by Lotfi Zadeh 1963
- Robinson Developed Complete Algorithm for Logical Reasoning, 1965
- GPS (General Problem Solver) by Newell and Simon 1969
- DENDRAL - First knowledge based expert system supported by NASA to determine the molecular structure of Mars soil. (Buchanan - 1969)
- Minsky, A framework for representing knowledge, 1975
- 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 –1970)

AI History

AI Winter (1985-1993)

- **Expert Systems Industry busts**

The rebirth of AI (1990 - onwards)

- **Hopfield, Neural Networks**
- **Kohonen, Self-Organized Maps (SOM)**
- **Rumelhart Parallel Distributed Processing**
- **Applications of GA and Fuzzy Logic in AI systems**

Predictions and Reality

- In 1958, Herbert Simon (CMU) predicted that within 10 years a computer would be Chess champion
- This prediction became true in 1997.
- Today, computers have won over world champions in several games, including Checkers, Othello, and Chess, but still do not do well in Go
- AI techniques (search, planning, probabilistic reasoning) are used in many video games

AI – The Achievements

- Robots make cars in all advanced countries.
- Reasonable machine translation is available for a large range of foreign web pages.
- Computers land 200 ton jumbo jets unaided every few minutes.
- Search systems like Google are not perfect but provide very effective information retrieval
- Robots cut slots for hip joints better than surgeons.
- Medical expert systems can outperform doctors in many areas of diagnosis.

AI – The Achievements

- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997.
- No hands across America (driving autonomously 98% of the time from Pittsburgh to San Diego).
- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people.
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft.
- Solves crossword puzzles better than most humans.

AI – A Comment

Despite all these achievements, one of the major philosophers of Cognitive Science wrote recently:

"… the failure of artificial intelligence to produce successful simulation of routine commonsense cognitive competences is notorious, not to say scandalous. We still don't have the fabled machine that can make breakfast without burning down the house; or the one that can translate everyday English into everyday Italian, or the one that can summarize texts.." **(Jerry Fodor, The Mind doesn't Work that Way, 2000, p.37).**

AI Trend

- Early AI concentrated on building intelligent machines that mimicked human behavior.
- Present AI devoted to embedding AI algorithms and techniques (neural networks, genetic algorithms, fuzzy logic, and intelligent agents) into software to provide them with the ability to learn, optimize, and reason.

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.
- **Metaknowledge:** Knowledge about knowledge, i.e., knowledge about what we know.

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.*

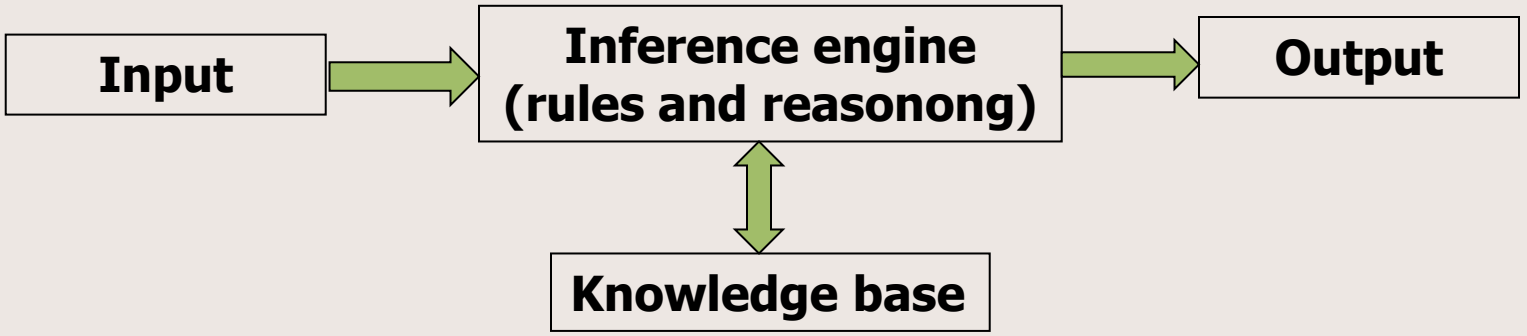
Knowledge should not be confused with data!

Example of Knowledge

- **Rita is tall:** **Expresses a simple fact, an attribute possessed by a person.**
- **Rafiq loves Rita:** **A binary relation between two persons.**
- **Liza has learned to use recursion to manipulate linked lists in several programming languages:** **Expressing relations between a person and more abstract programming concepts.**

Knowledge-Based 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.



Components of a knowledge-based system.

knowledge in Expert Systems

Conventional Programming	Knowledge-Based Systems
Algorithms + Data Structures = Programs	Knowledge + Inference = Expert System

Example 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)

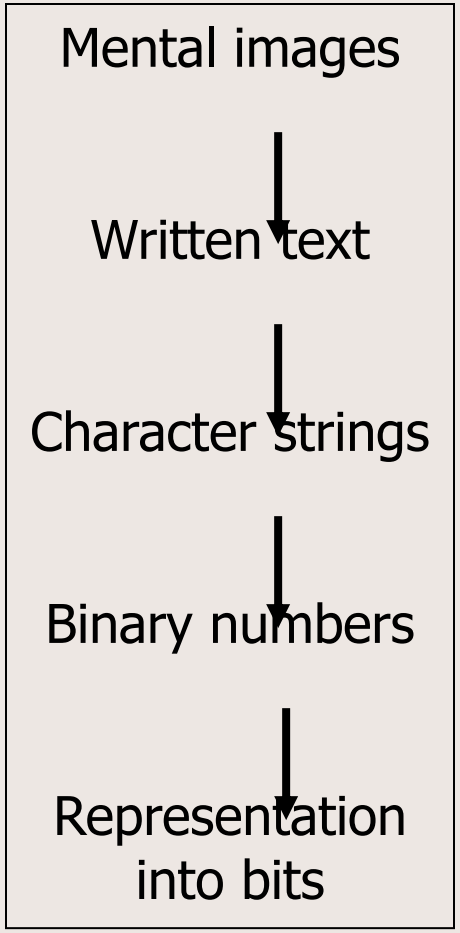
Rules as Knowledge Representation

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'

John is the father of Jim



Different levels of knowledge representation

FATHER(john,jim) : Representation of a fatherhood family relationship

Organization of Knowledge

- The fact or condition of knowing something with familiarity gained through experience or association.
- 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.

Manipulation of Knowledge

- Decisions and actions in knowledge-based systems come from manipulation of the knowledge in specified ways. Typically some form of input will initiate a search for a goal or decision. This requires that known facts in the knowledge-base be located, compared (matched), and possibly altered in some way.
- Manipulations are the computational equivalent of reasoning. All forms of reasoning require a certain amount of searching and matching.

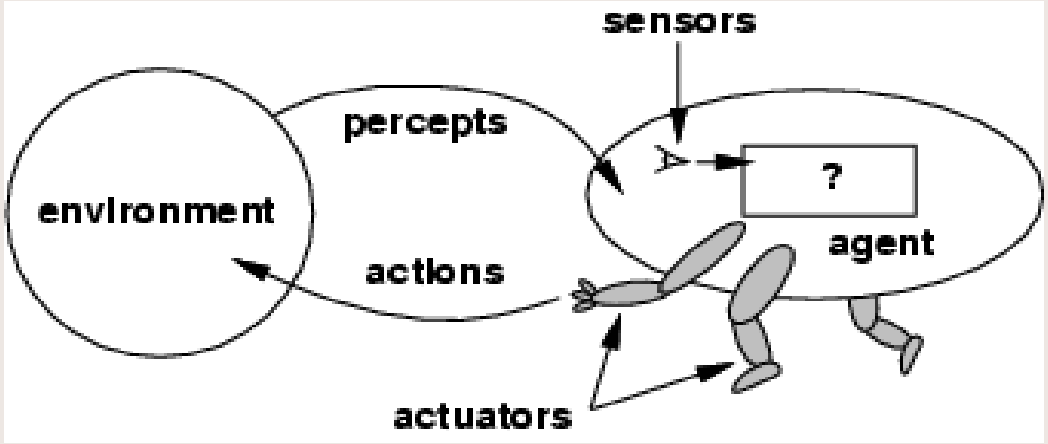
Acquisition of Knowledge

- One of the greatest bottlenecks in building knowledge-rich systems is the acquisition and validation of the knowledge.
- Knowledge can come from various sources, such as experts, textbooks, reports, technical articles, etc.

Intelligent Agents

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.
- Human agent: eyes, ears, and other organs for sensors and hands, legs, mouth, and other body parts for actuators.
- Robotic agent: cameras and infrared range finders for sensors and various motors for actuators.
- Software agent: Keystrokes, file contents, and network packets as sensors and displaying on the screen, writing files, and sending network packets as actuators.

Intelligent Agents and Environments



- The agent function maps from percept histories to actions:
  $[f: P^* \rightarrow A]$
- The agent program runs on the physical architecture to produce *f*
- agent = architecture + program

Characteristics of an Intelligent Agent (1)

- Agents are **autonomous**, that is, they act on behalf of the user.
- Agents contain some level of **intelligence**, from fixed rules to learning engines that allow them to adapt to changes in the environment.
- Agents don't only act **reactively**, but sometimes also **proactively.**

Characteristics of an Intelligent Agent (2)

- Agents have **social ability**, that is, they communicate with the user, the system, and other agents as required.
- Agents may also **cooperate** with other agents to carry out more complex tasks than they themselves can handle .
- Agents may **migrate** from one system to another to access remote resources or even to meet other agents.

Agent types

Four basic kinds of intelligent agents:

- Simple reflex agents responds directly what it percepts.

- Model-based reflex agents maintain internal state to track aspects of the world that are not evident in the current percept.

  For example: brake lights of vehicles at night.

- Goal-based agents act to achieve their goals.
  - Goal information needed to make decisions

- Utility-based agents try to maximize their own expected "happiness"
  - How well can the goal be achieved (degree of happiness)
  - What to do if there are conflicting goals?
  - Which goal should be selected if several can be achieved?

All agents can improve their performance through learning.

PEAS of Rational Agents

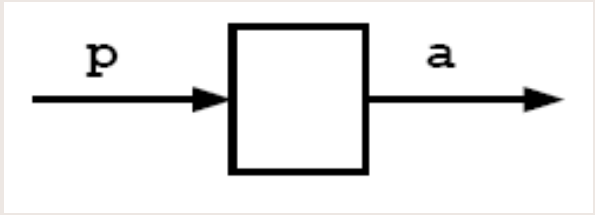
- PEAS: Performance measure, Environment, Actuators, Sensors.
- Must first specify the setting for intelligent agent design

PEAS Descriptions

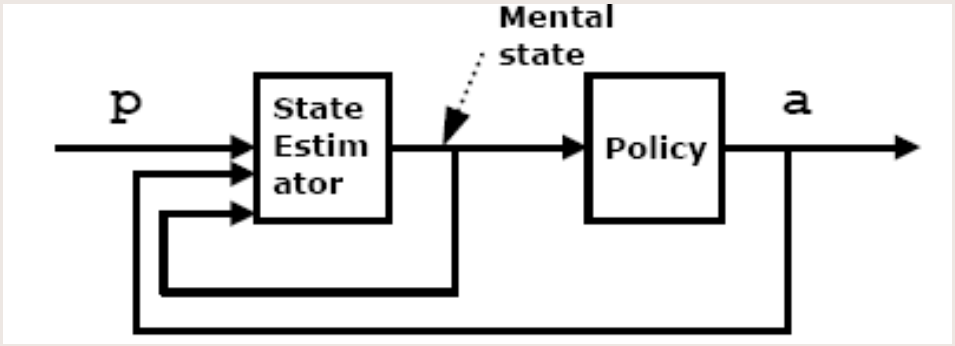
Agent Type	Performance Measure	Environment	Actuators	Sensors
Automated Taxi				
Taxi driver	Safe, fast, legal, comfortable trip, maximize profit	Roads, other traffic, pedestrians, customers	Steering, accelerator, brake, signal horn, display	Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, key board
Medical Diagnosis System				
Medical diagnosis system	Healthy patient, minimize costs, lawsuits	Patient, hospital, staff	Display, questions, tests, diagnoses, treatments, referrals	Key board entry of symptoms, findings, patient's answers

Agents

- Reactive agents
  - No memory

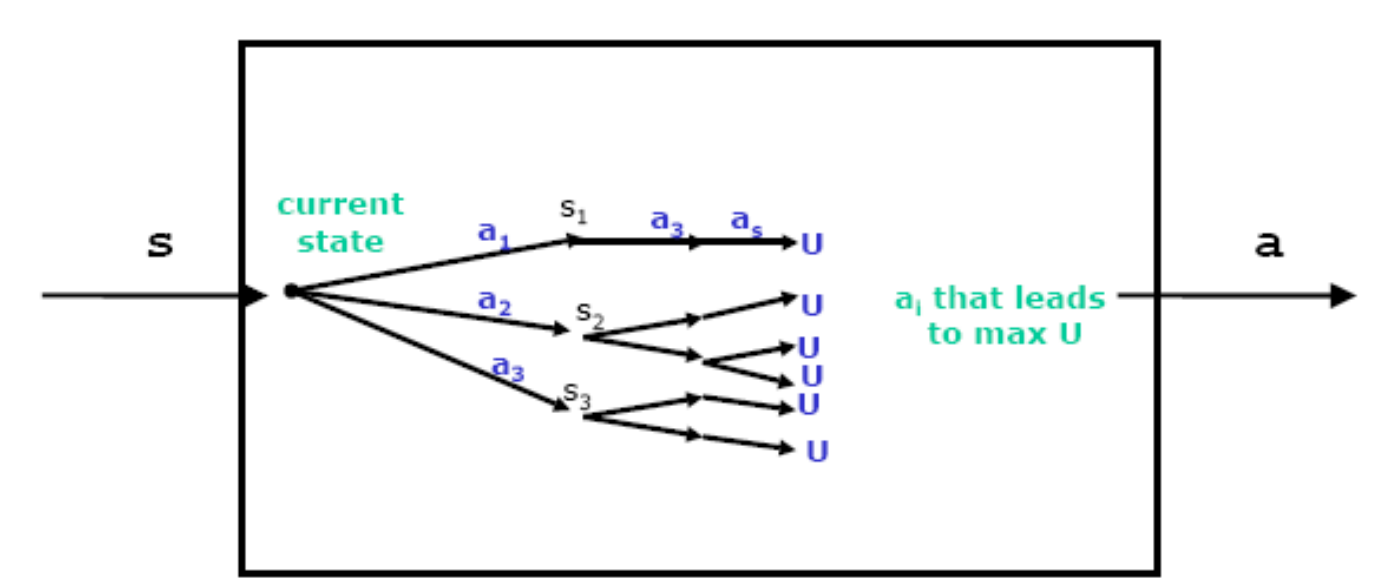


- Agents with memory



Planning

- Planning a policy = considering the future consequences of actions to choose the best



Environment Types

- Fully observable (vs. partially observable): An agent's sensors give it access to the complete state of the environment at each point in time.
- Deterministic (vs. stochastic): The next state of the environment is completely determined by the current state and the action executed by the agent. (If the environment is deterministic except for the actions of other agents, then the environment is strategic).
- Episodic (vs. sequential): The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself.

Environment Types

- Static (vs. dynamic): The environment is unchanged while an agent is deliberating. (The environment is semi-dynamic if the environment itself does not change with the passage of time but the agent's performance score does).
- Discrete (vs. continuous): A limited number of distinct, clearly defined percepts and actions.
- Single agent (vs. multiagent): A single agent operating by itself in an environment.

Towards Autonomous Vehicles

http://iLab.usc.edu

http://beobots.org

Interacting Agents

Collision Avoidance Agent (CAA)

- Goals: Avoid running into obstacles
- Percepts: Obstacle distance, velocity, trajectory
- Sensors: Vision, proximity sensing
- Effectors (Actuators): Steering Wheel, Accelerator, Brakes, Horn, Headlights
- Actions: Steer, speed up, brake, blow horn, signal (headlights)
- Environment: Freeway

Interacting Agents

Lane Keeping Agent (LKA)

- Goals: Stay in current lane
- Percepts: Lane center, lane boundaries
- Sensors: Vision
- Effectors: Steering Wheel, Accelerator, Brakes
- Actions: Steer, speed up, brake
- Environment: Freeway

Conflict Resolution by Action
(Selection of Agents in muli-agent environment)

- **Override:** CAA overrides LKA
- **Arbitrate:** if Obstacle is Close then CAA
  else LKA
- **Compromise:** Choose action that satisfies both agents
- **Challenges:** Doing the right thing

What is logic?

"Logic is the beginning of wisdom, not the end"

The branch of philosophy concerned with analysing the patterns of reasoning by which a conclusion is drawn from a set of premises, without reference to meaning or context is known as logic.

(***Collins English Dictionary***)

Why is logic important?

- Logic is a **formal method for reasoning**.
- Logic is a formal language for **deducing** knowledge from a small number of explicitly stated **premises** (or hypotheses, axioms, facts).
- Logic provides a formal framework for **representing knowledge.**
- Logic differentiates between the **structure** and **content** of an argument.

What is an argument?

- An argument is just a **sequence of statements.**
- Some of these statements, the **premises**, are assumed to be true and serve as a basis for accepting another statement of the argument, called the **conclusion.**

Deduction and Inference

- If the conclusion is justified, based solely on the premises, the process of reasoning is called **deduction.**
- If the validity of the conclusion is based on *generalisation* from the premises, based on strong but inconclusive evidence, the process is called **inference** (sometimes called **induction**).

Two examples

- **Deductive** argument:

  "Alexandria is a port or a holiday resort. Alexandria is not a port. Therefore, Alexandria is a holiday resort."

- **Inductive** argument

  "Most students who did not do the tutorial questions will fail the exam. John did not do the tutorial questions. Therefore John will fail the exam."

Foundation of Logic

Mathematical Logic is a tool for working with compound statements. It includes:

- A formal language for expressing them.
- A methodology for objectively reasoning about their truth or falsity.
- It is the foundation for expressing formal proofs in all branches of mathematics.

We will talk about two logical systems:

- Propositional logic
- Predicate logic

Propositional Inference

- Assume you are given the following two statements:
  - "you are in this class"
  - "if you are in this class, you will get a grade"

- Let p = "you are in this class"
- Let q = "you will get a grade"

- By Modus Ponens, you can conclude that you will get a grade

$$\begin{array}{l} p \\ \underline{p \rightarrow q} \\ \therefore\ q \end{array}$$

Predicate Logic

- *Predicate logic* is an extension of propositional logic that permits quantification over classes of entities.
- Propositional logic (recall) treats *simple propositions* (sentences) as atomic entities.
- A 'predicate' is just a property
- Predicates define relationships between any number of entities using qualifiers:

  ∀ "for all", "for every"

  ∃ "there exists"

  Remember:

  ∀ ***x*** **'for every *x*', or 'for <u>A</u>ll *x*'**

  ∃ ***x*** **'there is an *x*' or 'there <u>E</u>xists an *x*'**

Predicate inference

- Suppose the KB contains just the following:

  $\forall x$ King(x) $\wedge$ Greedy(x) $\Rightarrow$ Evil(x)

  King(John)

  Greedy(John)

  Brother(Richard,John)

- Instantiating the universal sentence in all possible ways, we have:

  King(John) $\wedge$ Greedy(John) $\Rightarrow$ Evil(John)

  King(Richard) $\wedge$ Greedy(Richard) $\Rightarrow$ Evil(Richard)

  King(John)

  Greedy(John)

  Brother(Richard,John)

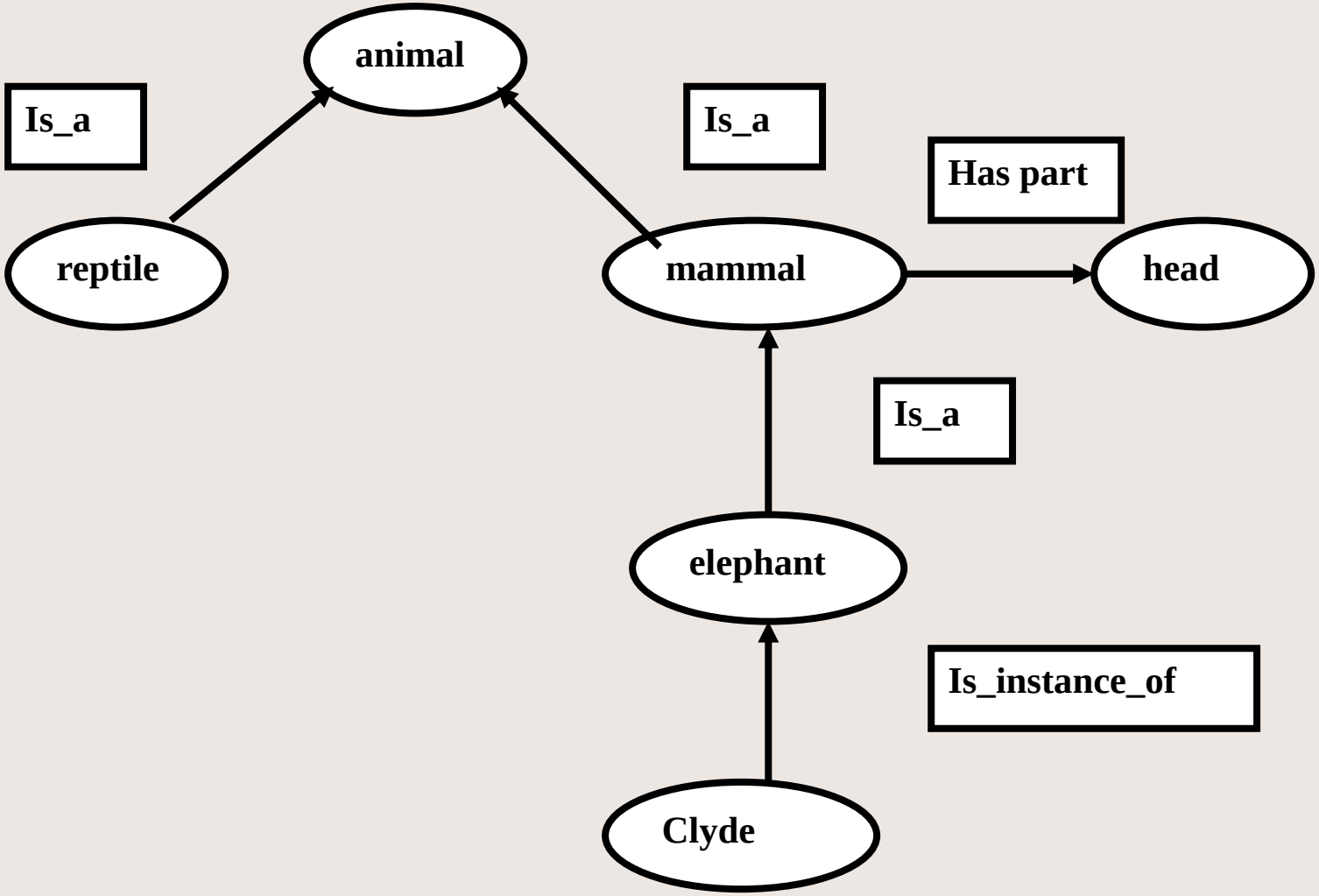
- The new KB is propositionalized: proposition symbols are

  John, Richard and also King(John), Greedy(John), Evil(John), King(Richard), etc.

KNOWLEDGE REPRESENTATION AND INFERENCE

- What is knowledge
- What is knowledge representation (KR)
- Knowledge representation languages
- Approaches to KR
  - Semantic networks /Graphs/ Associative Networks
  - Frames
  - Predicate Logic/Fuzzy Logic
  - Production Rules

Semantic networks /Graphs/ Associative Networks



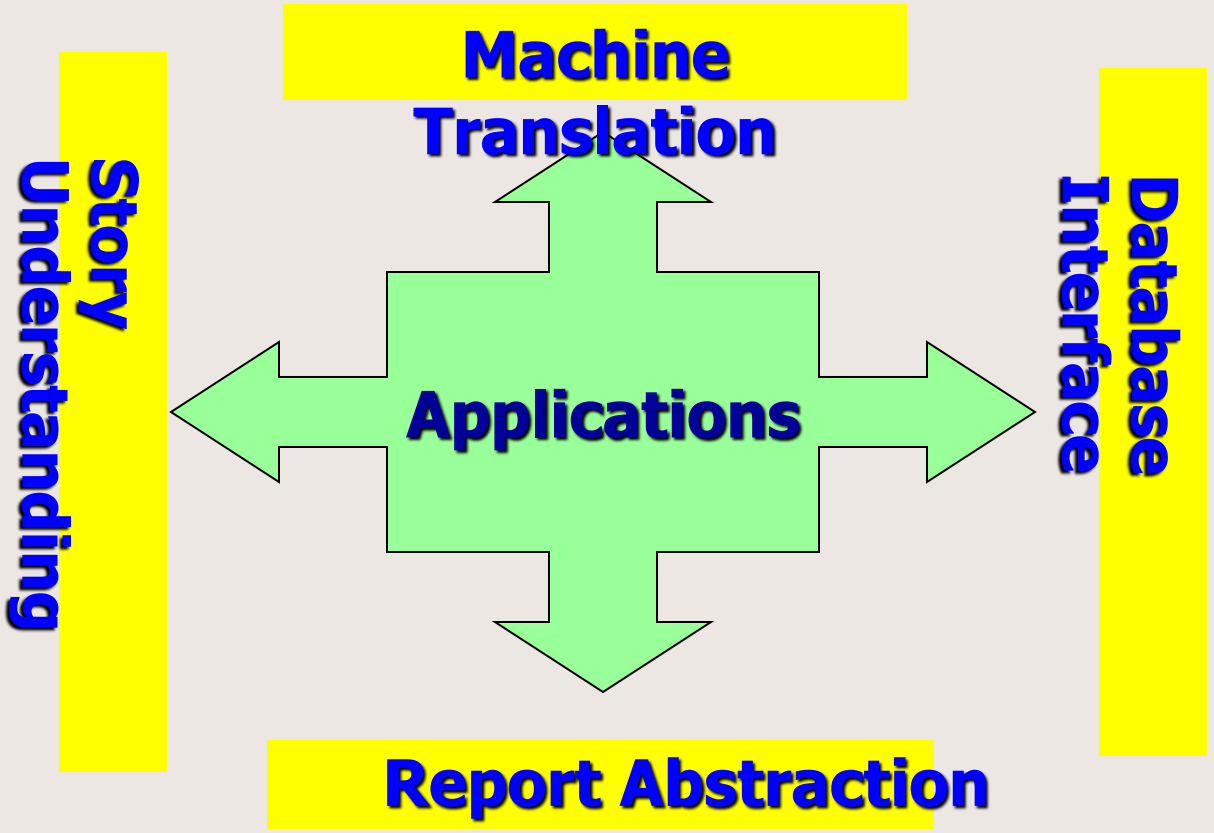
Frames

```
Mammal
   subclass:       Animal
   warm_blooded:   yes

Elephant
   subclass:       Mammal
   * colour:       grey
   * size:         large

Clyde
   instance:       Elephant
   color:          pink
   owner:          Fred
```

Natural Language Processing (NLP)

- Word, lexicon: lexical analysis
  - Morphology, word segmentation
- Syntax
  - Sentence structure, phrase, grammar, …
- Semantics
  - Meaning
  - Execute commands
- Discourse analysis
  - Meaning of a text
  - Relationship between sentences (e.g. anaphora)

Motivation


Machine Translation
Story Understanding
Applications
Database Interface
Report Abstraction

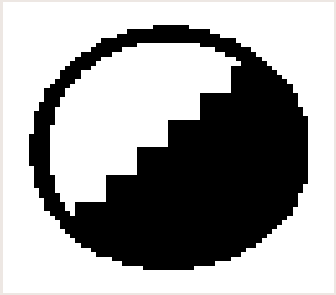
Applications

- Detect new words
- Language learning
- Machine translation
- NL interface
- Information retrieval
- …

NLP Stages

Morphological Analysis

Individual words are analyzed into their components



Stages of NLP

Discourse Analysis

Resolving references Between sentences

Syntactic Analysis

Linear sequences of words are transformed into structures that show how the words relate to each other

Semantic Analysis

A transformation is made from the input text to an internal representation that reflects the meaning

Pragmatic Analysis

To reinterpret what was said to what was actually meant

NLP Methods

- Morphological analyzer (Tokenization)
- Parser (Syntactic analysis)
- Semantic analysis (Transform into a logical form, lexical and compositional form, semantic network, etc.)
- Discourse analysis
- Pragmatic analysis

Example

Surface form

I want to print Ali's .init file

Stems (Tokenization)

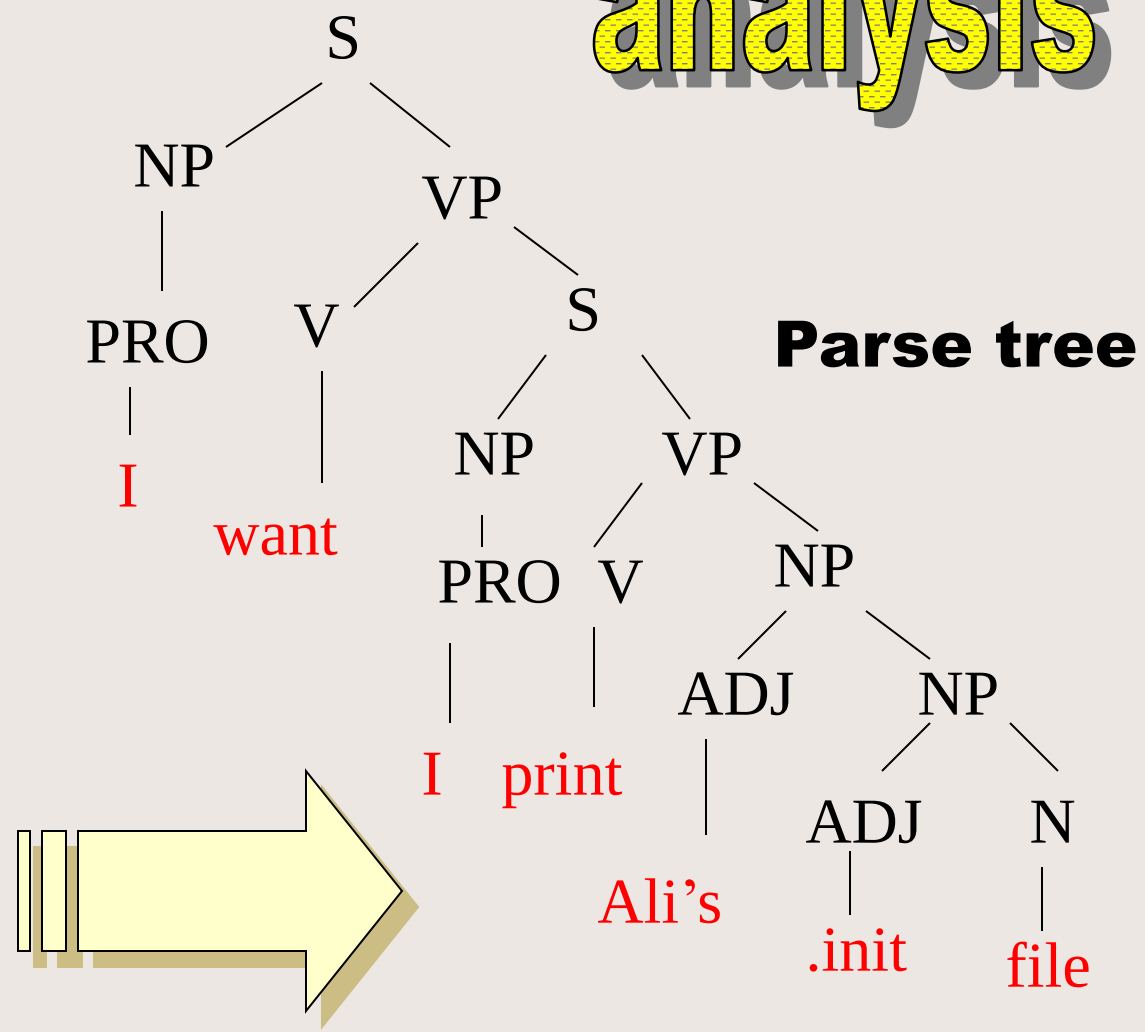
I (pronoun) want (verb)
to (prep)
to (infinitive) print (verb)
Ali (noun)
's (possessive) .init (adj)
file (noun)
file (verb)

Example

Syntactic analysis

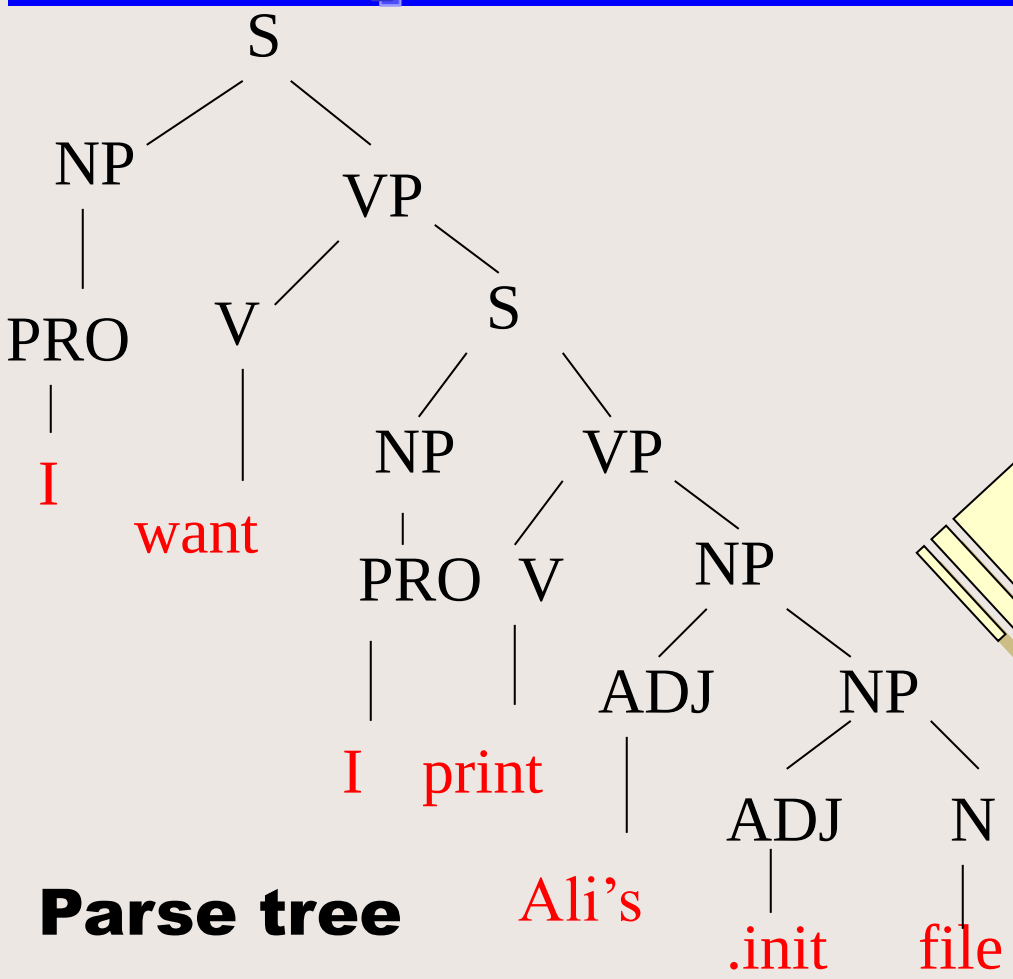
Stems

I (pronoun)
want (verb)
to (prep)
to (infinitive)
pr(lexical and compositional)
int (verb)
Ali (noun)
‘s (possessive)
.init (adj)
file (noun)
file (verb)

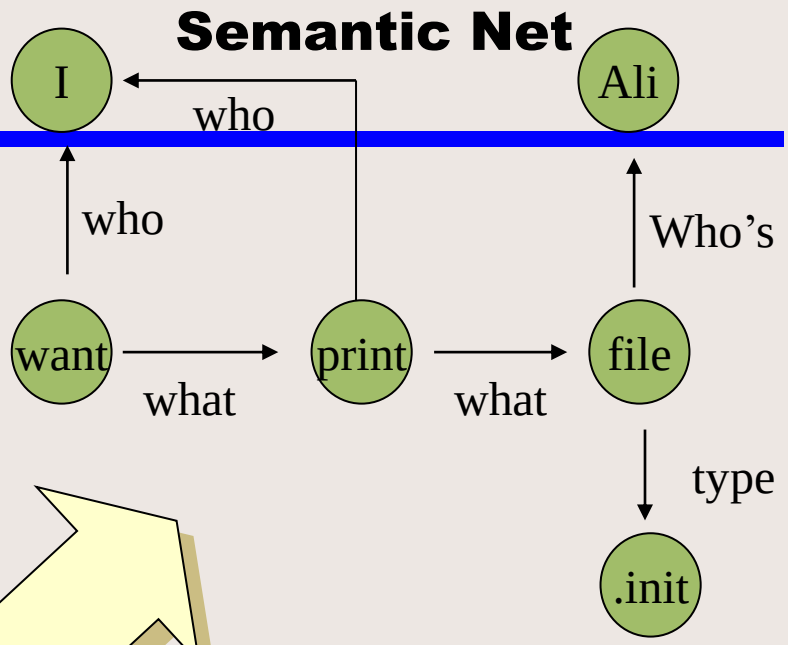


Parse tree

Example



Parse tree



Semantic analysis

(lexical and compositional)

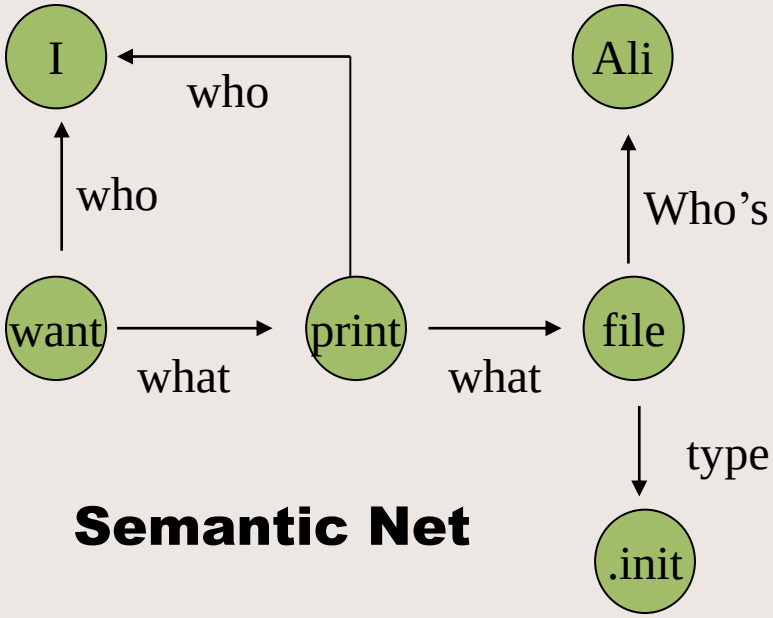
Example

Discourse

To whom the pronoun ‘I’ refers

To whom the proper noun ‘Ali’ refers

What are the files to be printed



Semantic Net

Pragmatic

Execute the command

```
lpr /ali/stuff.init
```

Learning

- Incomplete information about the environment
- A changing environment
- Use the sequence of percepts to estimate the missing details
- Hard for us to articulate the knowledge needed to build AI systems – e.g. try writing a program to recognize visual input like various types of flowers

What is Learning?

- Herb Simon-

  "Learning denotes changes in the system that are adaptive in the sense that they enable the system to do the tasks drawn from the same population more efficiently and more effectively the next time."

- But why do we believe we have the license to predict the future?

Why “Learn”?

- Machine learning is programming computers to optimize a performance criterion using example data or past experience.
- There is no need to “learn” to calculate payroll
- Learning is used when:
  - Human expertise does not exist (navigating on Mars),
  - Humans are unable to explain their expertise (speech recognition)
  - Solution changes in time (routing on a computer network)
  - Solution needs to be adapted to particular cases (user biometrics)

What is Machine Learning?

- Machine Learning
  - Study of algorithms that
  - improve their performance
  - at some task
  - with experience
- Optimize a performance criterion using example data or past experience.
- Role of Statistics: Inference from a sample
- Role of Computer science: Efficient algorithms to
  - Solve the optimization problem
  - Representing and evaluating the model for inference

Machine Learning Classification

- Association Analysis
- Supervised Learning
  - Classification
  - Regression/Prediction
- Unsupervised Learning
- Reinforcement Learning

Classifying Learning Problems

- Supervised learning- Given a set of input/output pairs, learn to predict the output if faced with a new input.
- Unsupervised Learning- Learning patterns in the input when no specific output values are supplied.
- Reinforcement Learning- Learn to interact with the world from the reinforcement you get.