Artificial Intelligence

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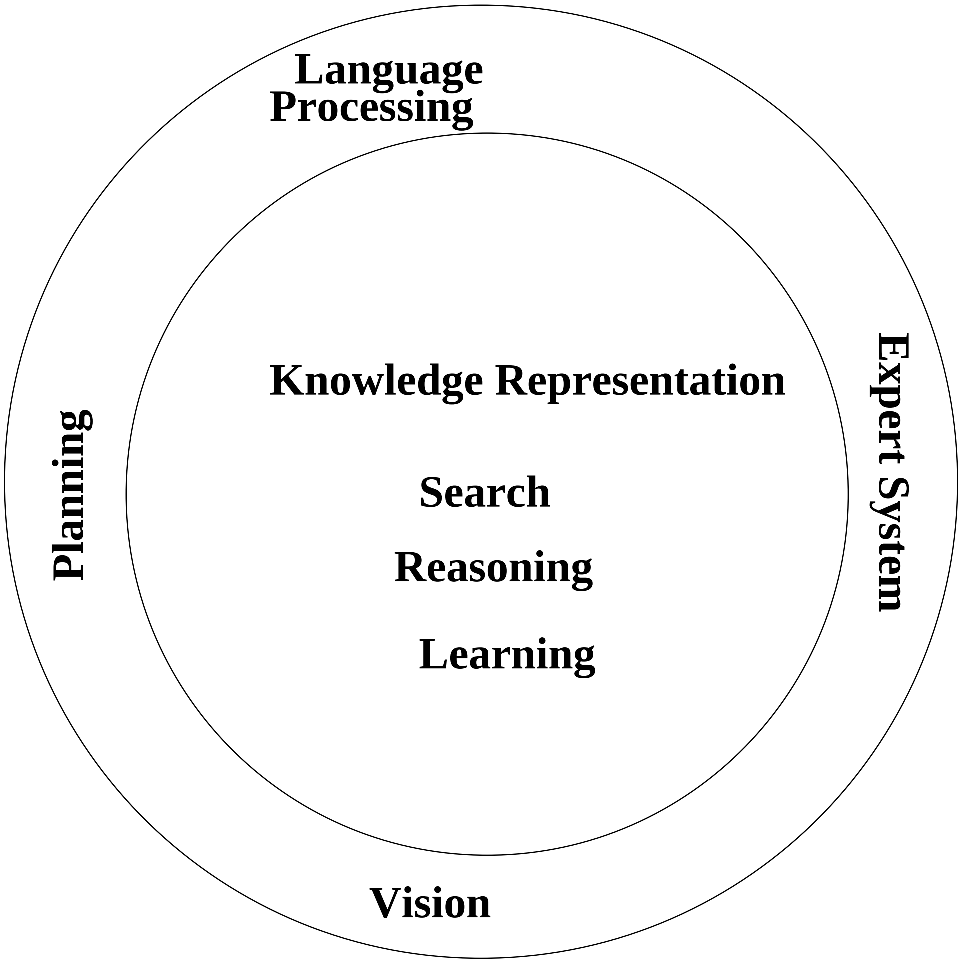
Goals of AI

- **Artificial Intelligence** is the study of how to make computers act *intelligently.*
- The field is interdisciplinary with inputs from Phillosphy, Mathematics, Physics, Cognitive Science, Computer Science and Engineering.
- The goals are
  - Engineering: Reduce Man-Machine gap.
  - Science+Engineering: Build Computer Models of Intelligence
  - Science: Understand Intelligence

Areas of AI


Language
Processing
Knowledge Representation
Search
Reasoning
Learning
Planning
Expert System
Vision

Requirements of AI System

- No system can be called intelligent unless it *learns* and *Reasons*.
- Reasoning derives new information from given ones.
- 3 kinds of reasoning:
  - *Deduction*: Given $P \to Q$ and P infer Q.
  - *Induction*: From special to general.
  - *Abduction*: Given $P \to Q$ and Q infer P, in absence of any other information. (Sherlock Holmes)

Knowledge Representation

- Importance realised during machine translation effort in 1950's.
- Dictionery look up and word replacement found inadequate. *Ambiguity* and *Ellipsis* problems.
- *Sprit is strong but flesh is weak.*
  English $\rightarrow$ Russian $\rightarrow$ English.

  Result: *The wine was good but the meat was rotten.*

Important Developments

- Foundational
  - Uncomputability: Limits to what an algorithm can do.
  - Godel's Theorem: Limits to what a formal system can do.
- Formal System consists of *Axioms, Rules of inference, Theorems.*
- Chess is a formal system.

Rule bases and Inferencing

- We use *Rules* everyday along with facts.
- Rules used to construct **Expert Systems**.
- *MYCIN*: used by doctors for initial diagnosis of diseases.
- Important components of ES are:
  - Backward chaining
  - Explanation Generation
  - Inference engine or Expert System Shells.

Logic

- Foundation of rule based representation and inferencing.
- Most important forms of logic are *Propositional* and *Predicate* Calculus.
- Inferencing is based on *Unification* and *Resolution.*
- *Quantifier* a very important development.
- The closest approximaton of human reasoning is *Non-monotonic logic.*

Example of Inferencing

Problem:

All members of Alpine Club are moutain climbers or skiers. Mountain Climbers do not like rain. Skiers like snow. A, B and C are members of Alpine club. A likes whatever B dislikes and dislikes whatever B likes. A likes snow and rain.

Is there a member of Alpine Club who is a mounain climber but not a skier?

Inferening: Club problem

Knowledge in clause form

$$\forall x(mc(x) V sk(x))$$

$$\forall x(mc(x) \rightarrow \ lk(x, rain)$$

$$\forall x(sk(x) \rightarrow lk(x, snow)$$

$$\forall y(lk(B, y) \rightarrow \ lk(A, y)$$

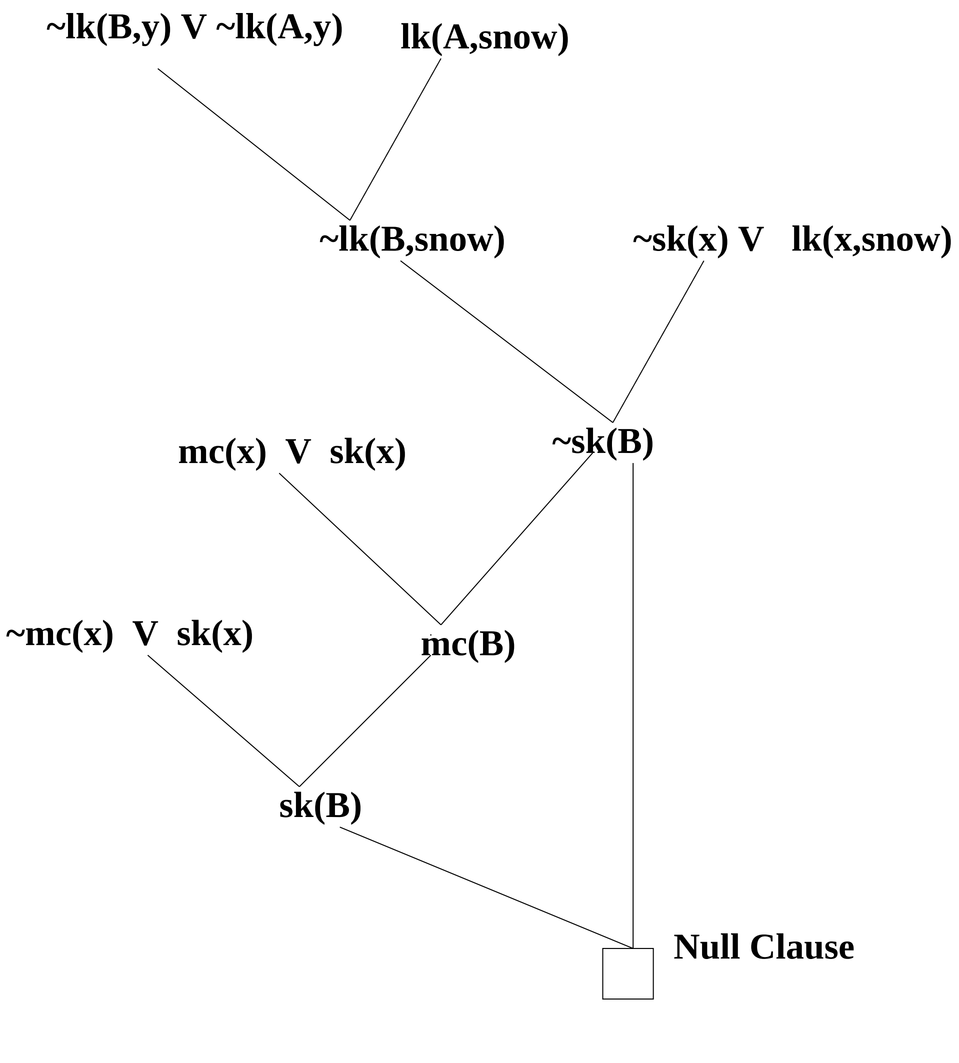
$$\forall y(\ lk(B, y) \rightarrow lk(B, y)$$

$$lk(A, snow)$$

$$lk(A, rain)$$

$$\exists x(mc(x) \wedge sk(x))?$$

Resolution Diagram

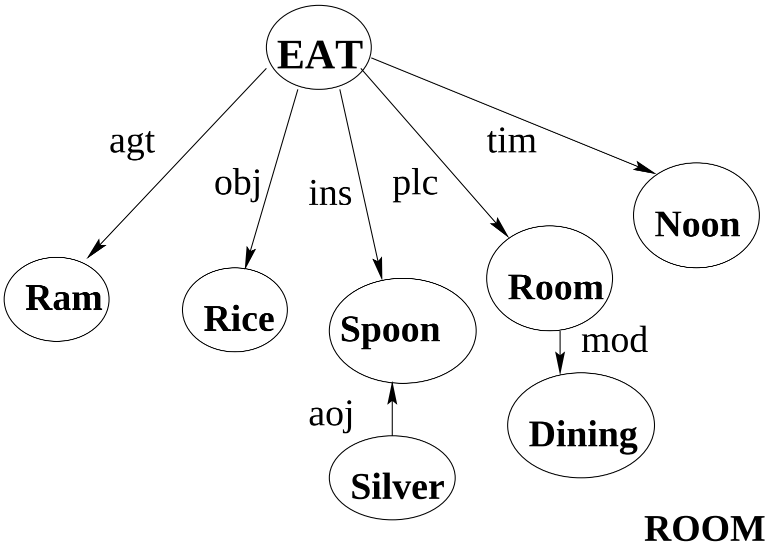


Structured Knowledge Representation

- Rule and Fact based representation unstructured.
- Related piece of knowledge not together at one place.
- *Semantic Nets* and *Frames* represent structured knowledge.
- Semantic nets are graph like structures with *concepts* as nodes and links labelled as *is-a* and *is-part-of*.
- *Declarative* and *Procedural* kinds of knowledge to be represented.

SN and Frame example

Ram was eating rice with a silver spoon in the dining room at noon



ROOM"

ACTION "EAT"
Agent: "Ram"
Object: "Rice"
Instrument: "Spoon"
Qualifier: "Silver"
Place: "Room"
Modifier: "Dining"
Time: "Noon"

Developments in NLP

- Problems to be dealt with in Written Communication: *Ambiguity, Polysemy, Ellipsis* and *Metaphors.*
- Speech understanding more difficult because of *word boundary* recognition. *I got up late I came here today* (Australian)
- NLP stages
  - Lexical
  - Syntactic
  - Semantic
  - Pragmatic

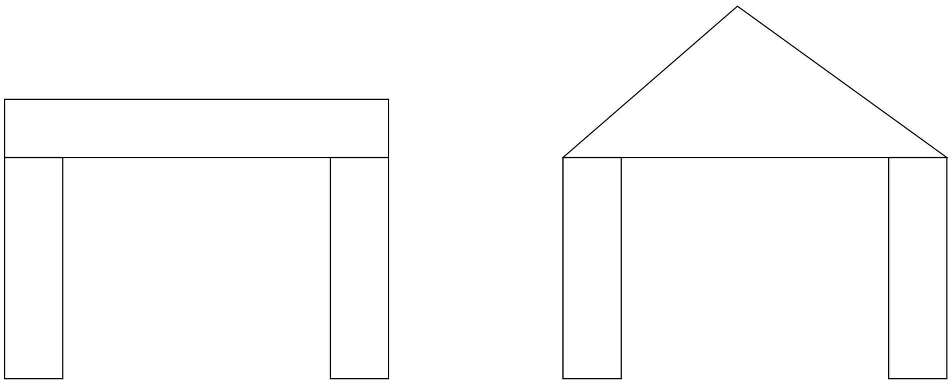
NLP applications and systems

- Broad areas
  - Queston answer
  - Story understanding
  - Interfaces
  - Internet
- Some famous applications: **SHRDLU** in blocks world and **LUNAR** interface to Data on Moon.

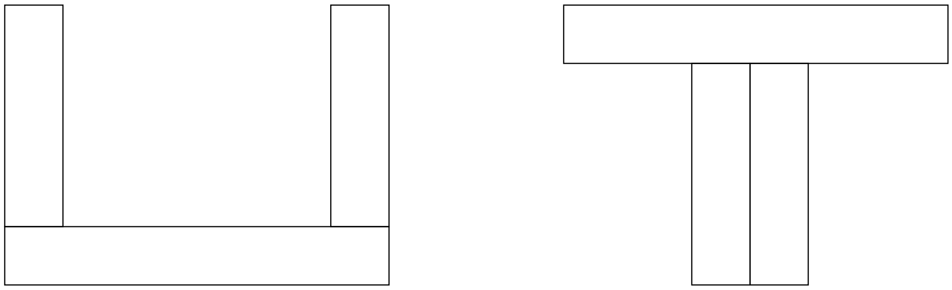
Learning

- *Concept* or *Skill* acquisition.
- Changing of internal state of the system in response to *positive* and/or *negative* examples.
- Two distinct phases: *Training* and *Testing*.
- Positive examples *generalize* while Negative examples *restrict*.
- *Near Miss* negative examples to be provided.
- Learning could be either *batch or offline* or *incremental or online*.

Learning Example



POSITIVE EXAMPLES OF ARCH



NEGATIVE EXAMPLES OF ARCH

Neural Networks

- Alternative model of computing- motivated by human brain.
- Human versus Computer Information Processing:

HUMANS	VON NEUMANN COMPUTERS
Multiple processors	Single Processor
Parallel and distributed processing	Serial Processing
Connections store memory	Locations store memory
Fault tolerant	Fragile
Data to Data Mapping	Address to Data Mapping

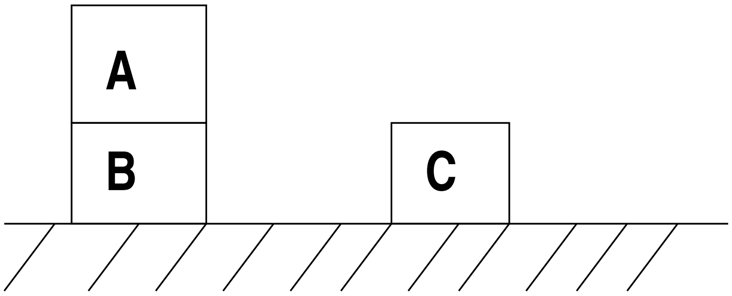
Models of Neural Computing

- Supervised
  - Perceptron
  - Feedforward Net with Back Propagation
  - Hopfield net
- Unsupervised
  - Adaptive Resonance Theory
  - Kohonen net

Planning

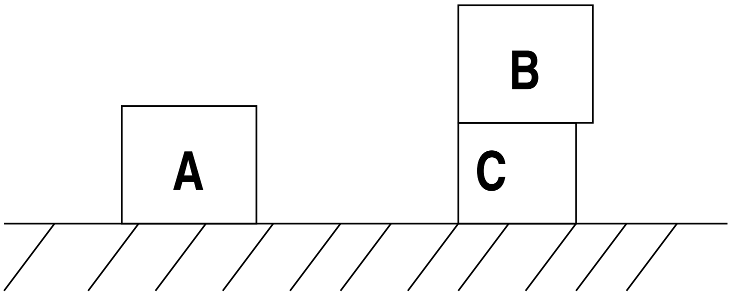
- *Plan*: A sequence of actions to achieve a paricular goal.
- Planning using
  - If-add-delete rules
  - Situation variables
- Famous planning system: *STRIPS*.

Planning example



ON(B,A)
ON(A,TABLE)
CLEAR(B)
CLEAR(C)

Inital State



ON(A,TABLE)
CLEAR(A)
ON(B,C)
CLEAR(B)

Final State

Operator

- A set of operators for the problem at hand is specified.

- $Operator_1$:
  Move block x from block y to block z.

- ```
      IF:  On (x,y)
           Clear(x)
           Clear(z)
     Add:  On(x,3)
           Clear(y)
  Delete:  On(x,y)
           Clear(z)
  ```
  ```

Vision

- Object recognition using image library.
- Matching different views.
- Edge Detection using the idea of Zero crossing.
- Stereo matching and distance estimation.
- Shape from shading.
- Correspondence Problem.

Books

- *Artificial Intelligence*, Rich and Knight (General Introduction and Reading).
- *Artificial Intelligence*, Charniack and Mcdermott (Knowledge Representation).
- *Principles of Artificial Intelligence*, N.J. Nilsson (Search and Logic).
- *Artificial Intelligence*, P.H. Winston (Vision).
- *Artificial Intelligence*, Lugart and Stubbfield (General Text Book).

Journals

- Artificial Intelligence Journal.
- Artificial Intelligence Magazine.
- IEEE Expert
- Machine Learning.
- Computational Linguistics
- Computer Vision Graphics and Image Processing.