Chapter-5: Structured Knowledge Representation

- Knowledge Representation is an area of AI whose fundamental goal is to represent knowledge in manner that facilitates inference i.e. drawing conclusion for knowledge.
- It analyzes how to think formally, how to use symbol to represent a domain of discourse along with function that allow inference about the objects.
- Knowledge representation helps to address the problem like:
  . How do we represent fact about the world?
  . How do we reason about them?
  . What representations are appropriate for dealing with the real world?
  . How to express knowledge in computer understandable form so that reasoning agent can perform well?

Knowledge Mappings

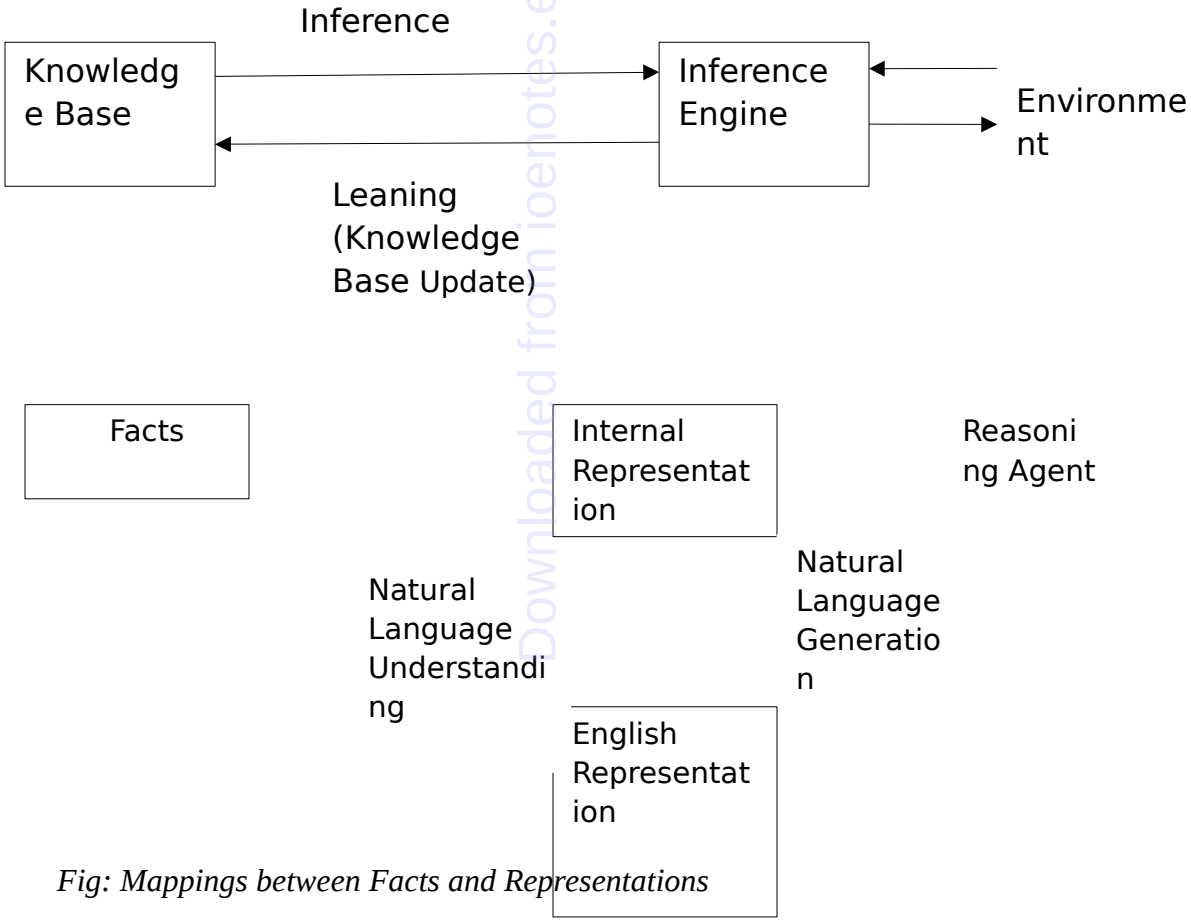

Fig: Mappings between Facts and Representations

Approaches to Knowledge Representation

A good system for knowledge representation should have

i. **Represential Adequacy:**
Ability to represent all kind of knowledge that are needed in the domain.

ii. **Inferential Adequacy:**
Ability to manipulate the represential structure in such a way as to derive new structures corresponding to new knowledge inferred from old.

iii. **Inferential Efficiency:**
Ability to incorporate into the knowledge structure additional information that can be used to focus the attention of the inference mechanism in the most efficient directions.

iv.

v. **Acquisitional Efficiency:**
Ability to acquire new information easily.

Knowledge Types:

a. Simple relational knowledge:
The simplest way to represent declarative facts is as a set of relations of the same sort used in database system.

b. Inheritable Knowledge
Structure must be designed to corresponding to the inference mechanism that are desired.

c. **Inferential Knowledge**
Represents knowledge as formal logic. Based on reasoning from facts or from other inferential knowledge. Useless unless there is also as inference procedure that can exploit it.

d. Procedural Knowledge (Imperative Knowledge)
Knowledge exercised in the performance of some task and processed by an intelligent agent.

Issues in Knowledge Representation

- Are any attributes of objects so basic that they have been occurred in almost every problem domain?
- Are there any important relationships that exist among attributes of objects?
- At what level should knowledge be represented?
- How should sets of objects be represented?
- How can relevant part be accessed when they are needed?

Knowledge can be viewed as different level.

i. **Knowledge Level:** The most abstract level that describe agent by saying what it knows. Eg: An intelligent taxi might know that the Bagmati bridge connects Thapathali with Kupondole.

ii. **Logical Level:** The level at which the knowledge is encoded into formal sentences. Eg: Links (Bagmati Bridge, Thapathali, Kupondole)

iii. **Implementation Level:** Physical Representation of the sentences in the logical level. Eg: Objets, Dam, Piller etc.

Knowledge Model

- A model is a world in which a sentence is true under a particular interpretation.
- There can be several models at once that have the same interpretation.

Types:

1. **First Order Predicate Logic**

- This consists of objects, predicates on objects, connectives and quantifiers
- Predicates are the relations between objects or properties of the objects.
- Connectives and quantifiers allows for universal sentences.
- Relation between objects can be true or false.

2. **Procedural Representation Model**

- This model of knowledge representation encodes facts along with the sequence of operations for manipulation and processing of the facts.
- Expert systems are based on this model.
- It works best when expert follows set of procedures for problem solving. Eg: A medical diagnosis system.

3. **Relational Representation Model**

- Collections of knowledge are stored in tabular form.
- Mostly used in commercial databases, relational databases.
- The information is manipulated with relational calculus using a language such as SQL, Oracle etc.
- This is flexible way to store information but not good for storing complex relationships.
- Problem arises when more than one subject area is attempted.
- A new knowledgebase from scratch has to be built for each area of expertise.

4. **Hierarchical Representation Model**

- Based on inherited knowledge and relationship and shared attributes between objects.
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5. **Semantic Nets**

- Semantic network is an alternative to predicate logic as a form of knowledge representation.
- The structure of a semantic net is shown graphically in terms of nodes and the arcs connecting them.
  . Nodes are sometimes referred to as objects.
  . Arcs represent the links or edges.
  . The links are used to express relationships.
- Two types of commonly used links are i. IS-A, and ii.A-KIND-OF
- IS-A means "is an instance of' and refers to a specific member of a class.

- The link A-KIND-OF is used here to relate one class to another .
- Nodes are to represent physical objects, concepts, or situation.
- The idea is that we can store our knowledge in the form of a graph, with nodes representing objects in the world, and arcs representing relationships between those objects.
- Semantic network is a declarative graphic representation that can be used to represent knowledge and support automated systems for reasoning about the knowledge
- For example, the following:
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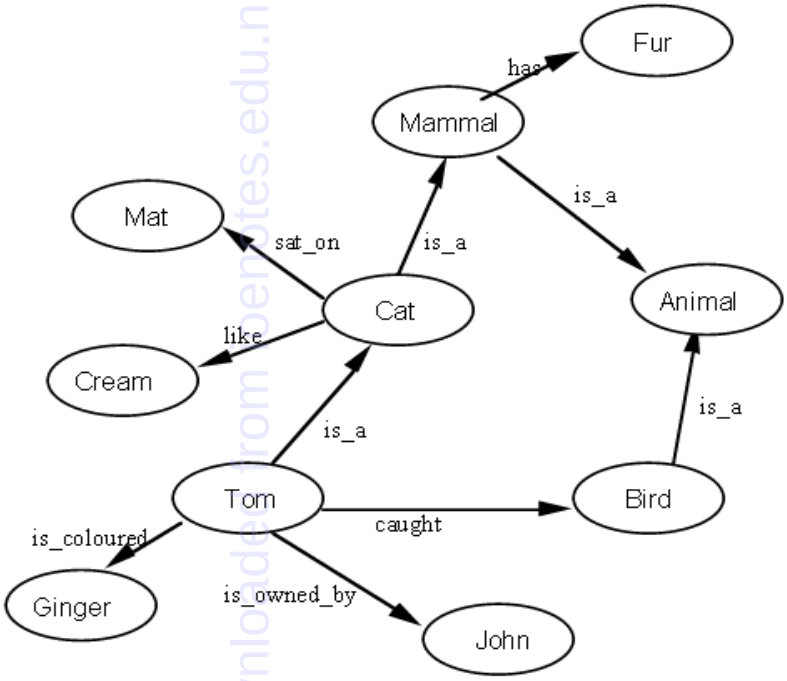


- Semantic Network is intended to represent the data:
- Tom is a cat.
- Tom caught a bird.
- Tom is owned by John.
- Tom is ginger in colour.
- Cats like cream.
- The cat sat on the mat.
- A cat is a mammal.
- A bird is an animal.
- All mammals are animals.
- Mammals have fur.
- It is argued that this form of representation is closer to the way human's structure knowledge.

Frames (slot and filler structure)

- Frame is a type of schema used in many AI applications including vision and natural language processing that provides a convenient structure for representing.
- Frame is similar to a record structure and corresponding to the fields and values are slots and slot fillers.
- Basically it is a group of slots and fillers that defines a stereotypical object.
- A single frame is not much useful. Frame systems usually have collection of frames connected to each other.
- Value of an attribute of one frame may be another frame.
- Frames are also useful for representing commonsense knowledge.
- While semantic nets are basically a two-dimensional representation of knowledge, frames add a third dimension by allowing nodes to have structures.
- By using frames in the filler slots and inheritance, very powerful knowledge representation systems can be built.
- Frame-based expert systems are very useful for representing causal knowledge because their information is organized by cause and effect.
- Frames are generally designed to represent either generic or specific knowledge.
- A frame for a book is given below.

Slots	Fillers
publisher	Thomson
title	Expert Systems
author	Giarratano
edition	Third
year	1998
pages	600

Conceptual Dependency (CD) (Strong slot and filler structure)

- Conceptual Dependency originally developed to represent knowledge acquired from natural language input.
- The goals of this theory are:
    - To help in the drawing of inference from sentences.
    - To be independent of the words used in the original input.
- For any 2 (or more) sentences that are identical in meaning there should be only one representation of that meaning.
- It has been used by many programs that portend to understand English.
- CD provides:

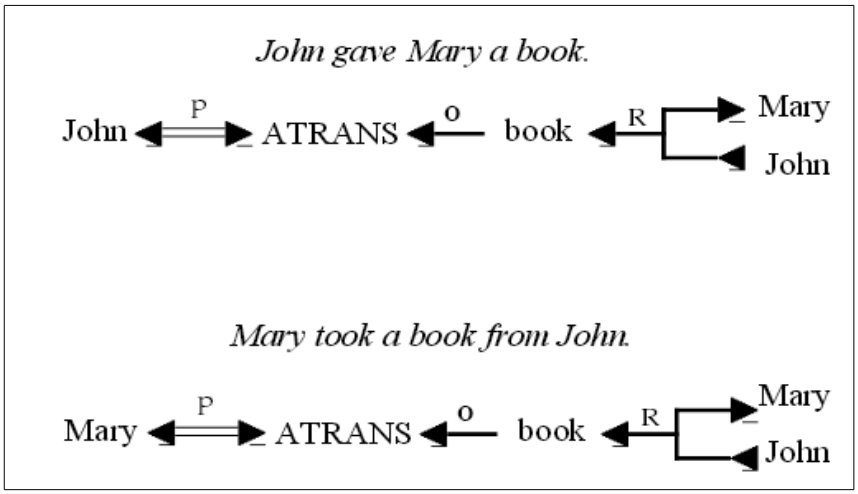
- a structure into which nodes representing information can be placed
- a specific set of primitives
- at a given level of granularity.

- Sentences are represented as a series of diagrams depicting actions using both abstract and real physical situations.
- The agent and the objects are represented.
- The actions are built up from a set of primitive acts which can be modified by tense.

Examples of Primitive Acts are:

ATRANS
-- Transfer of an abstract relationship. *e.g. give*.
PTRANS
-- Transfer of the physical location of an object. *e.g. go*.
PROPEL
-- Application of a physical force to an object. *e.g. push*.
MTRANS
-- Transfer of mental information. *e.g. tell*.
MBUILD
-- Construct new information from old. *e.g. decide*.
SPEAK
-- Utter a sound. *e.g. say*.
ATTEND
-- Focus a sense on a stimulus. *e.g. listen, watch*.
MOVE
-- Movement of a body part by owner. *e.g. punch, kick*.
GRASP
-- Actor grasping an object. *e.g. clutch*.
INGEST
-- Actor ingesting an object. *e.g. eat*.
EXPEL
-- Actor getting rid of an object from body. *e.g. throw*

Example:



SCRIPT

A script is a remembered precedent, consisting of tightly coupled, expectation-suggesting primitive-action and state change frames [Winston, 1992]
A script is a structured representation describing a stereotyped sequence of events in a particular context [Luger, Stubblefield, 1998, p.324]
That is, extend frames by explicitly representing expectations of actions and state changes.
Find primitives to describe the world like PTRANS for "transfer physical location of an object (= go)" and ATRANS for "transfer a relationship (= give)".

A Restaurant Script

Script: RESTAURANT	
Track: Coffee Shop Props: Tables Menu F=Food Check Money Roles S=Customer W=Waiter C=Cook M=Cashier O=Owner	Entry cond.: S hungry S has money Results: S has less money O has more money S is not hungry S is pleased (optional)
Scene 1: Entering S PTRANS S into restaurant S ATTEND eyes to tables S MBUILD where to sit S PTRANS S to table S MOVE S to sitting position	**Scene 2: Order** (Menu on table) (W brings menu) S PTRANS menu to S S MTRANS food list to S S MTRANS signal to W W PTRANS W to table S MTRANS 'I want F' to W
Scene 3: Eating C ATRANS F to W W ATRANS F to S S INGEST F (Option: Return to Scene 2 to order more; otherwise, go to Scene 4)	**Scene 4: Exiting** W MOVE (write check) W PTRANS W to S W ATRANS check to S S ATRANS tip to S S PTRANS S to M S ATRANS money to M

	S PTRANS S to out of restaurant