Knowledge and Reasoning

Unit 3

Knowledge Base

- It contains domain-specific and high-quality knowledge.

- Knowledge is required to exhibit intelligence. The success of any individuals majorly depends upon the collection of highly accurate and precise knowledge.

    What is Knowledge?

    The data is collection of facts. The information is organized as data and facts about the task domain. **Data, information,** and **past experience** combined together are termed as knowledge

- Components of Knowledge Base
- The knowledge base of an ES is a store of both, factual and heuristic knowledge.
- **Factual Knowledge** − It is the information widely accepted by the Knowledge Engineers and scholars in the task domain.
- **Heuristic Knowledge** − It is about practice, accurate judgement, one's ability of evaluation, and guessing.

Knowledge representation

- The classic methods of representing knowledge use either rules or logic.

- It is the method used to organize and formalize the knowledge in the knowledge base. It is in the form of IF-THEN-ELSE rules.

- The KB representation should be able to handle this sort Of environment, "here limited or partial Information is available the beginning and later on. more information is evolved.
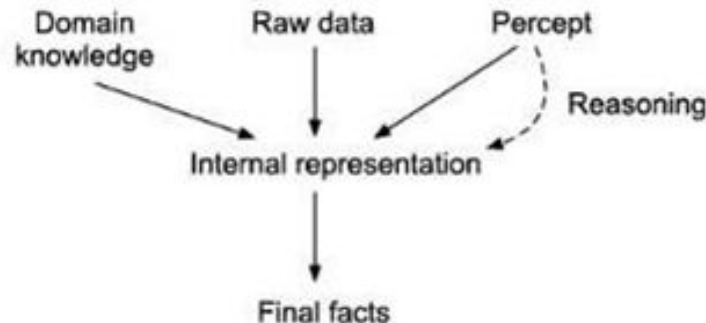

Fig.1 Knowledge building and representation

Approaches and Issues of knowledge representation

Approaches

- While designing a system for knowledge representation we would always go for a system that allows representation of the entire knowledge, which is required with respect to the application or domain we work on, usually known as adequacy in terms of representation.

- It needs to be efficient in terms of inferring, where the additional data is used in direction of better inferring.

- The representation need to be adaptive and also available at the point of time.

Approaches

Relational knowledge structure
- The facts are mapped into the relations and stored in the database
- It is the weak inference mechanism

Employee	Salary	Experience
Sameer	30000	3
Kavita	20000	2
Jasmin	20000	2

Inheritable knowledge structure
- Relational knowledge is made up of objects consisting of attributes and corresponding associated values.

- Property inheritance
  - elements inherit values from being members of a class.
  - data must be organised into a hierarchy of classes
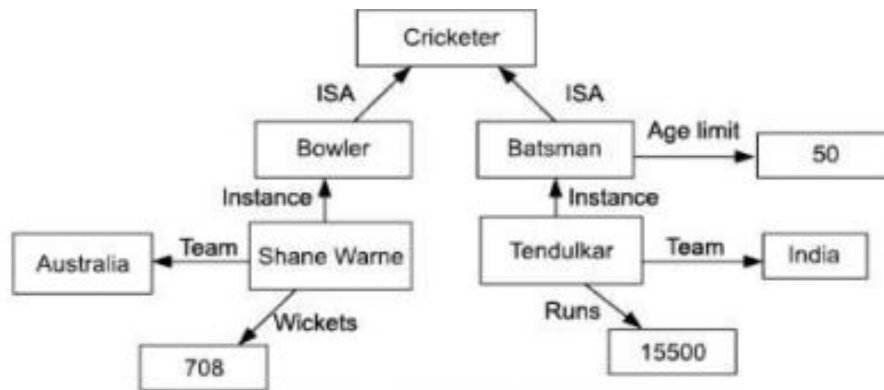
- Boxed nodes -- objects and values of attributes of objects.
- Values can be objects with attributes and so on.
- Arrows -- point from object to its value.
- This structure is known as a slot and filler structure, semantic network or a collection of frames.

  This structure is also called the slot-filler structure

Inferential knowledge structure

- First order logic is used for better utilization of knowledge

|	Rule	First-order logic
R1	IF animal has hair THEN species is mammal	$\forall x\, \text{Has\_hair}(x) \Rightarrow \text{Mammal}(x)$
R2	IF animal gives milk THEN species is mammal	$\forall x\, \text{Gives\_milk}(x) \Rightarrow \text{Mammal}(x)$
R3	IF animal eats meat THEN species type is carnivore	$\forall x\, \text{Eats\_meat}(x) \Rightarrow \text{Carnivore}(x)$
R4	IF animal has pointed teeth AND animal has claws AND animal has forward eyes THEN species type is carnivore	$\forall x\, \text{Has\_pointed\_teeth}(x) \wedge \text{Has\_claws}(x)$ $\wedge \text{Has\_forward\_eyes}(x) \Rightarrow \text{Carnivore}(x)$
R5	IF animal is mammal AND animal has hooves THEN mammal group is ungulate	$\forall x\, \text{Mammal}(x) \wedge \text{Has\_hooves}(x)$ $\Rightarrow \text{Ungulate}(x)$

Procedural knowledge structure

- It is used when we need to have knowledge in detailed form
- Programming languages are used(LISP is the most common language used for this purpose).

Issues

Issues that arises while KR techniques:

- Important Attributes:
    - Most important Attributes have an impact on the representation
    - So it is important understand and identify these attributes
- Relationships among Attributes.
    - Identifying the relationships among the attributes is equally important
    - The relationship between the attributes of an object, independent of specific knowledge they encode, may hold properties like : Inverse, Existence in an isa hierarchy , Technique for reasoning about values and Single valued attributes
- Choosing the granularity of Representation.
    - Up to what depth the mapping of the knowledge is to be done.

- **Representing Sets of Objects.**
  - The reason to represent sets of objects is: if a property is true for all or most elements of a set, then it is more efficient to associate it once with the set rather than to associate it explicitly with every elements of the set.

- **Finding the Right structures as Needed.**
  - Given a large amount of knowledge stored in a database, how can relevant parts are accessed when they are needed?
  - This is about access to right structure for describing a particular situation.
  - This requires, selecting an initial structure and then revising the choice.
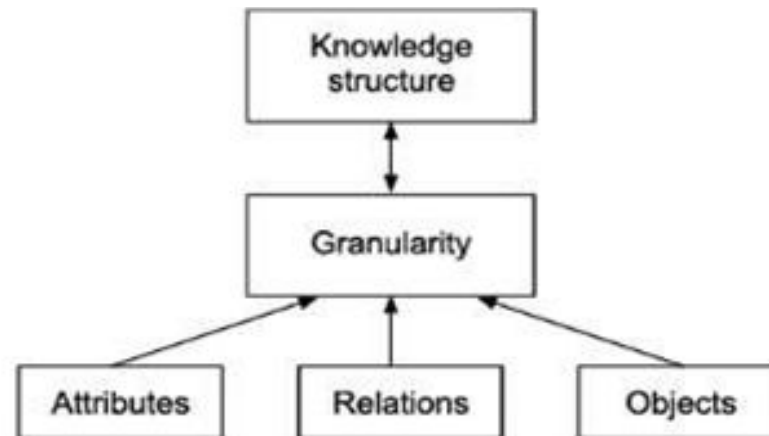
Knowledge based agent

- A knowledge-based agent includes a knowledge base and an inference system.
- A knowledge base is a set of representations of facts of the world.
- Each individual representation is called a **sentence**.
- The sentences are expressed in a **knowledge representation language**.

- The agent operates as follows:
    1. It TELLs the knowledge base what it perceives.
    2. It ASKs the knowledge base what action it should perform.
    3. It performs the chosen action.

Logic

Logic involves syntax, semantics as well as inference procedures.

There is a need to define logical involvement in two sentences or facts

Ex: Assume x and y two sentences whose relationship is to be determined. So let us map this relationship as follows:

$$x \models y$$

This indicates that the sentence x entails y, indicating that in the model when x is true the y is also true.

Propositional logic

- One popular choice is use of logic.

- Propositional logic is the simplest.

  - Symbols represent facts: P, Q, etc..

  - These are joined by logical connectives (and, or, implication) e.g., $P \wedge Q$; $Q \Rightarrow R$

  - Given some statements in the logic we can deduce new facts (e.g., from above deduce R)

Propositional logic

- Syntactic Properties of Propositional Logic
  - If S is a sentence, ¬S is a sentence (negation)
  - If S1 and S2 are sentences, S1 $\wedge$ S2 is a sentence (conjunction)
  - If S1 and S2 are sentences, S1 $\vee$ S2 is a sentence (disjunction)
  - If S1 and S2 are sentences, S1 $\Rightarrow$ S2 is a sentence (implication)
  - If S1 and S2 are sentences, S1 $\Leftrightarrow$ S2 is a sentence (bi-conditional)

Semantic Properties of Propositional Logic

- $\neg$S is true iff   S is false
- S1 $\wedge$ S2 is true iff   S1 is true and S2 is true
- S1 $\vee$ S2 is true iff   S1is true or S2 is true
- S1 $\Rightarrow$ S2 is true iff   S1 is false or S2 is true
- i.e., is false iff   S1 is true and S2is false
- S1 $\Leftrightarrow$ S2is true iff   S1$\Rightarrow$S2 is true

  and S2$\Rightarrow$S1 is true