Knowledge Representation

Lecture 3

Outline

- Knowledge Representation
- Properties of Representation Systems
- Approaches to Knowledge Representation
- Knowledge Representation Types

Knowledge representation

A subarea of Artificial Intelligence concerned with understanding, designing, and implementing ways of representing information in computers so that programs (agents) can use this information

- to derive information that is implied by it,

- to converse with people in <mark>natural languages</mark>,

- to decide what to do next

- to plan future activities,

- to solve problems in areas that normally require human expertise.

- **What to Represent?**

Let us first consider what kinds of knowledge might need to be represented in AI systems:

- **Objects**
  - -- Facts about objects in our world domain. *e.g.* Guitars have strings, trumpets are brass instruments.
- **Events**
  - -- Actions that occur in our world. *e.g.* Steve played the guitar in Frank Zappa's Band.
- **Performance**
  - -- A behaviour like *playing the guitar* involves knowledge about how to do things.
- **Meta-knowledge**
  - -- knowledge about what we know.

Properties of Knowledge Representation

- Representational adequacy

  – ability to represent the required knowledge

- Inferential adequacy

  – ability to manipulate knowledge

- Inferential efficiency

  – ability to respond with limited resources (time, storage)

- Acquisitional efficiency

  – ability to acquire new knowledge

Approaches to Knowledge representation

1. Simple Relational Knowledge

The simplest way of storing facts is to use a relational method where each fact about a set of objects is set out systematically in columns.

| Musician	Style	Instrument	Age
Miles Davis	Jazz	Trumpet	deceased
John Zorn	Avant Garde	Saxophone	35
Frank Zappa	Rock	Guitar	deceased
John Mclaughlin	Jazz	Guitar	47

2. Inheritable Knowledge

Relational knowledge is made up of objects consisting of attributes and associated values.

Elements inherit values from being members of a class.

Boxed nodes -- objects and values of Attributes.

Arrows -- point from object to its value.
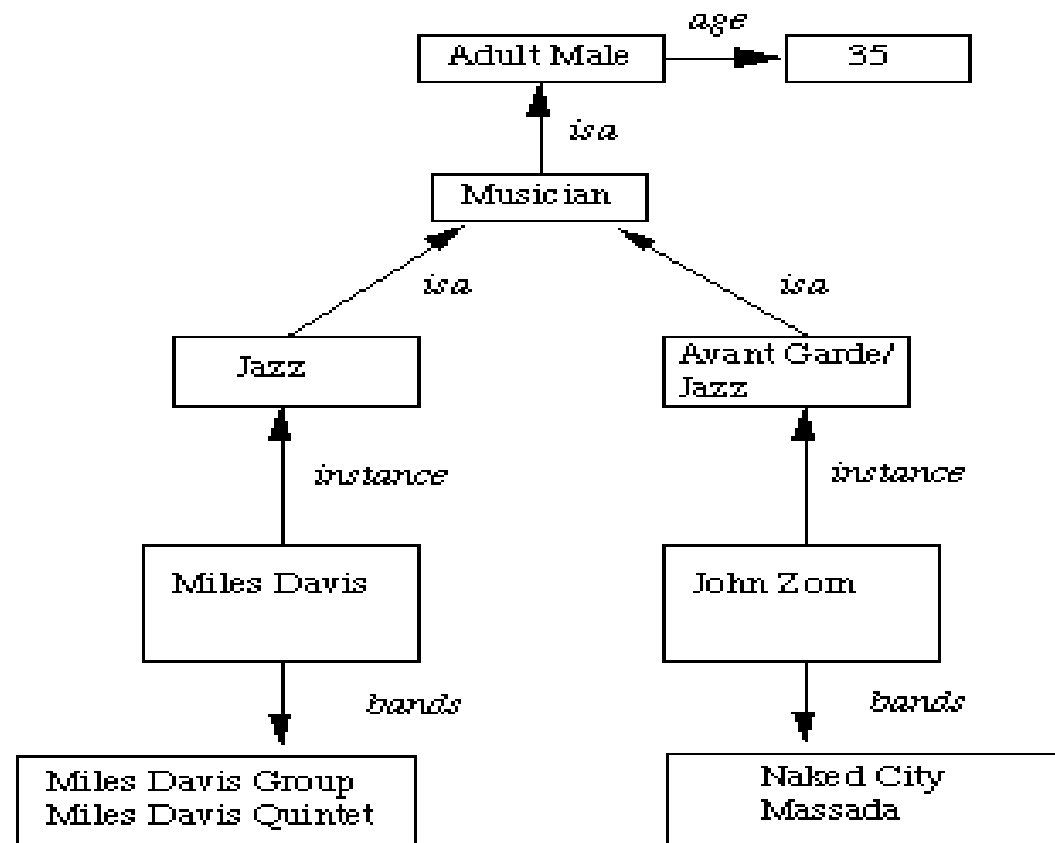
3. Inferential Knowledge

Represent knowledge as formal logic.

For example, *All dogs have tails, can be represented as*

$V(X) : dog(x) \rightarrow has\text{-}a\text{-}tail(x)$

4. Procedural Knowledge

- Knowledge encoded in some procedures -
  - small programs that know how to do specific things, how to proceed
  - In this approach, one important rule is used which is **If-Then rule**

Types of Knowledge representation

The Knowledge Representation is generally of four types -

- Logical Representations

Logical representation means drawing a conclusion based on various conditions.

- Semantic Networks

In Semantic networks, we can represent our knowledge in the form of graphical networks. This network consists of nodes representing objects and arcs which describe the relationship between those objects.

- Production Rules

Production rules system consist of (**condition, action**) pairs which mean, "If condition then action".

- Frames

A frame is a record like structure which consists of a collection of attributes and its values to describe an entity in the world.

Knowledge Representation

Lecture -3

What is knowledge representation?

- Humans are best at understanding, reasoning, and interpreting knowledge. Human knows things, which is knowledge and as per their knowledge they perform various actions in the real world. **But how machines do all these things comes under knowledge representation and reasoning**. Hence we can describe Knowledge representation as following:

- Knowledge representation and reasoning (KR, KRR) is the part of Artificial intelligence which concerned with AI agents thinking and how thinking contributes to intelligent behavior of agents.

- It is responsible for representing information about the real world so that a computer can understand and can utilize this knowledge to solve the complex real world problems such as diagnosis a medical condition or communicating with humans in natural language.

- It is also a way which describes how we can represent knowledge in artificial intelligence. Knowledge representation is not just storing data into some database, but it also enables an intelligent machine to learn from that knowledge and experiences so that it can behave intelligently like a human.

What to Represent:

- Following are the kind of knowledge which needs to be represented in AI systems:
- **Object:** All the facts about objects in our world domain. E.g., Guitars contains strings, trumpets are brass instruments.
- **Events:** Events are the actions which occur in our world.
- **Performance:** It describe behavior which involves knowledge about how to do things.
- **Meta-knowledge:** It is knowledge about what we know.
- **Facts:** Facts are the truths about the real world and what we represent.
- **Knowledge-Base:** The central component of the knowledge-based agents is the knowledge base. It is represented as KB. The Knowledgebase is a group of the Sentences (Here, sentences are used as a technical term and not identical with the English language).

Types of knowledge

1. Declarative Knowledge:

- Declarative knowledge is to know about something.

- It includes concepts, facts, and objects.

- It is also called **descriptive knowledge** and expressed in declarative sentences.

- It is simpler than procedural language.

Types of knowledge

2. Procedural Knowledge

- It is also known as **imperative knowledge**.

- Procedural knowledge is a type of knowledge which is responsible for knowing **how to do something**.

- It can be directly applied to any task.

- It includes **rules**, strategies, procedures, agendas, etc.

- Procedural knowledge depends on the task on which it can be applied.

3. Meta-knowledge:

- Knowledge about the other types of knowledge is called Meta-knowledge.

Types of knowledge

4. Heuristic knowledge:

- Heuristic knowledge is representing knowledge of some experts in a filed or subject.
- Heuristic knowledge is **rules of thumb** based on previous experiences, awareness of approaches, and which are good to work but not guaranteed.

5. Structural knowledge:

- Structural knowledge is **basic knowledge to problem-solving**.
- It describes relationships between various concepts such as kind of, part of, and grouping of something.
- It describes the relationship that exists between concepts or objects.

The relation between knowledge and intelligence:

- Knowledge plays an important role in demonstrating intelligent behavior in AI agents. An agent is only able to accurately act on some input when he has some **knowledge** or experience about that input.

- Let's suppose if you met some person who is speaking in a language which you don't know, then how you will able to act on that. The same thing applies to the intelligent behavior of the agents.
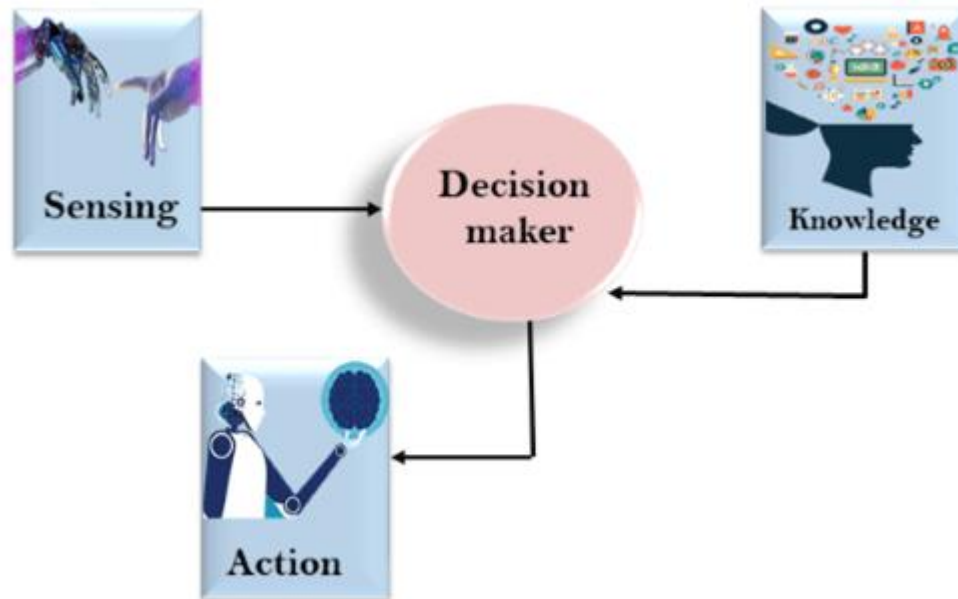
Approaches to knowledge representation

- There are mainly four approaches to knowledge representation, which are given below:

1. **Simple relational knowledge:**

- It is the simplest way of storing facts which uses the **relational** method, and each fact about a set of the object is set out systematically in columns.

- This approach of knowledge representation is famous in **database systems** where the relationship between different entities is represented.

- This approach has little opportunity for **inference**.

Approaches to knowledge representation

- **Example: The following is the simple relational knowledge representation.**

| Player	Weight	Age
Player1	65	23
Player2	58	18
Player3	75	24

Approaches to knowledge representation

2. **Inheritable knowledge:**

- In the inheritable knowledge approach, all data must be stored into a **hierarchy** of classes.

- All classes should be arranged in a generalized form or a hierarchal manner.

- In this approach, we apply inheritance property.

- **Elements inherit values from other members of a class**.

- This approach contains inheritable knowledge which shows a relation between instance and class, and it is called instance relation.

- Every individual frame can represent the collection of attributes and its value.

- In this approach, objects and values are represented in Boxed nodes.

- We use Arrows which point from objects to their values.

Inheritable knowledge

- **Example:**
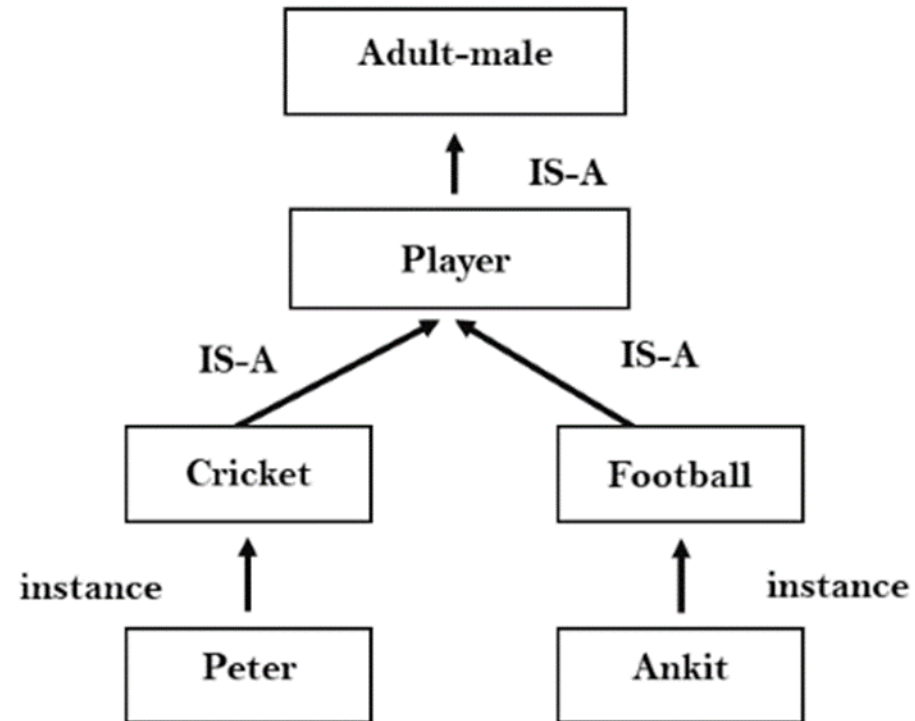
Inferential knowledge

- Inferential knowledge approach represents knowledge in the form of **formal logics**.

- This approach can be used to derive more facts.

- It guaranteed correctness.

- **Example:** Let's suppose there are two statements:
  - Marcus is a man
  - All men are mortal
    Then it can represent as;

    man(Marcus)
    ∀x = man (x) ----------> mortal (x)s

Procedural knowledge

- Procedural knowledge approach uses small programs and codes which describes how to do specific things, and how to proceed.

- In this approach, one important rule is used which is **If-Then rule**.

- In this knowledge, we can use various coding languages such as **LISP language** and **Prolog language**.

- We can easily represent heuristic or domain-specific knowledge using this approach.

- But it is not necessary that we can represent all cases in this approach.

Requirements for knowledge Representation system

- A good knowledge representation system must possess the following properties.

1. Representational Accuracy:
   KR system should have the ability to represent all kind of required knowledge.

2. Inferential Adequacy:
   KR system should have ability to manipulate the representational structures to produce new knowledge corresponding to existing structure.

3. Inferential Efficiency:
   The ability to direct the inferential knowledge mechanism into the most productive directions by storing appropriate guides.

4. Acquisitional efficiency:
   The ability to acquire the new knowledge easily using automatic methods.