Artificial Intelligence

Lecture - 9

▶ # Knowledge Representation

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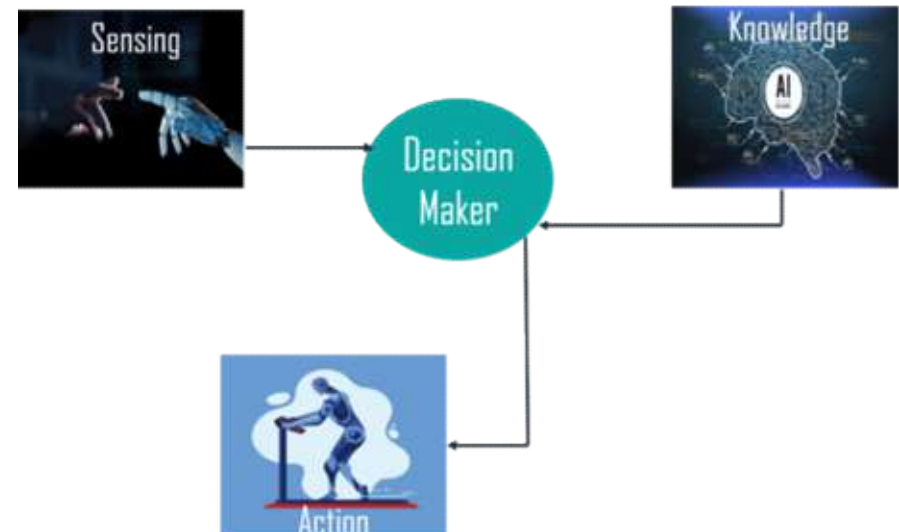   Dept. of CSE,   Jatiya Kabi Kazi Nazrul Islam University

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Lecture Outlines

- …
- Knowledge & Intelligence
- Knowledge Representation
- Levels of Knowledge & KR
- Knowledge Base & Management
- Knowledge-based Agent
- Database vs Knowledge-base
- Applications of Knowledge-base
- …

Knowledge & Intelligence

- **What is the Relation between Knowledge & Intelligence?**
  - As we know earlier, knowledge plays a vital role in intelligence as well as creating artificial intelligence.
  - It demonstrates the intelligent behavior in **AI agents or systems**. It is possible for an agent or system **to act accurately on some input only when it has the knowledge** or experience about the input.

- Let's take an example to understand the relationship:
  - There is one **decision-maker** whose **actions** are justified by **sensing the environment** and **using knowledge**.
  - But, if we remove the knowledge part here, it will not be able to display any intelligent behavior.

Knowledge Representation…

- **How to represent knowledge?**

- Knowledge representation (KR) is the study of

  - **how knowledge and facts** about the world can be represented, and

  - **what kinds of reasoning** can be done with that knowledge.

- The topic "**how to represent knowledge**" requires an analysis to distinguish between **knowledge "how"** and **knowledge "that"**.

  o **"how to do something"**. e.g. "how to drive a car" is Procedural knowledge.

  o **that something is true or false".** e.g. "that is the speed limit for a car on a motorway" is Declarative knowledge.

Knowledge Representation…

- Basically, it is a study of how the **beliefs, intentions**, and **judgments** of an **intelligent agent** can be expressed suitably for automated reasoning. One of the primary purposes of Knowledge Representation includes **modeling intelligent behavior for an agent.** It is **the method used to encode knowledge** in an intelligent system's knowledge base.

- Knowledge Representation and Reasoning (**KR, KRR**) represents information from the real world for a computer to understand and then utilize this knowledge to solve **complex real-life problems** like communicating with human beings in natural language.

- Knowledge representation in AI is not just about storing data in a database, it allows a machine to learn from that knowledge and behave intelligently like a human being.
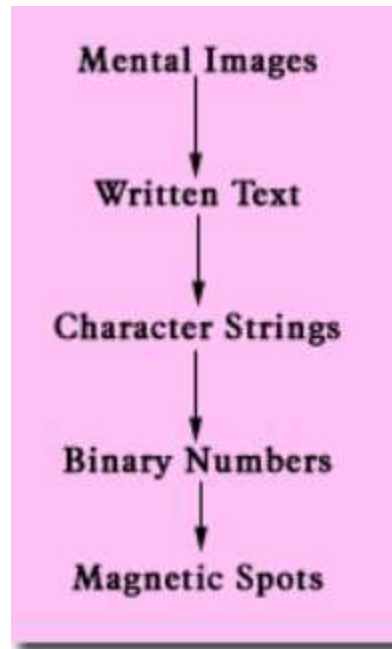
Knowledge Representation…

- **Goals:**

- We want a knowledge representation that is:

  - **rich enough to express the knowledge** needed to solve the problem.

  - **as close to the problem as possible**: compact, natural and maintainable, amenable to efficient computation.

  - **able to express features of the problem.**

  - **able to trade off accuracy and computation time.**

Knowledge Representation

- A representation consists of four fundamental parts:

  - **A lexical part** that determines which symbols are allowed in the representation's vocabulary.

  - **A structural part** that describes constraints on how the symbols can be arranged.

  - **A procedural part** that specifies access procedures that enable to create descriptions, to modify them, and to answer questions using them.

  - **A semantic part** that establishes a way of associating meaning with the description.

Levels of KR

- As we know that knowledge consists of facts, concepts, rules, and so forth. It can be represented by different forms in the different levels, as mental image, as spoken or written words in some language, as graphical or other pictures, and as character strings or collection of magnetic spots stored in a computer.

The different levels of KR

Knowledge Levels…

- **Newell's 3 levels of knowledge:**
  - Newell distinguished 3 levels in the context of knowledge representation:
    - **Knowledge Level**
    - **Logical Level**
    - **Implementation Level**
- **Brachman's 5 levels of knowledge:**
  - Brachman defines 5 levels for different types of representations. These levels interpret the transition from data to knowledge and each level corresponds to an explicit set of primitives offered to the knowledge engineer.
  - Ordering of knowledge levels from simple/abstract to complex/concrete:
    - **Implementational Level**
    - **Logical Level**
    - **Epistemological Level**
    - **Conceptual Level**
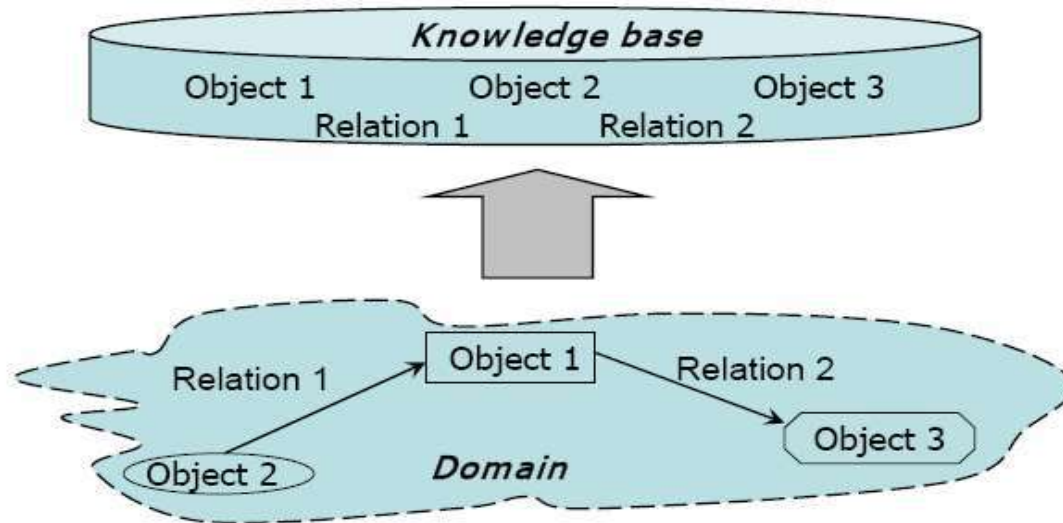   - **Linguistic Level**

Knowledge Levels…

- **Newell's 3 levels of knowledge:**
  - **Knowledge Level:**
    - The most abstract level of representing knowledge. It concerns the total knowledge contained in the Knowledge Base.
    - Example: The automated BD-Information system knows that a trip from Dhaka to CoxsBazar costs Tk.1000.
  - **Logical Level:**
    - Encoding of knowledge in a formal language.
    - Example: Price(Dhaka, CoxsBazar, 1000)
  - **Implementation Level:**
    - The internal representation of the sentences.
    - Example: As a String "Price(Dhaka, CoxsBazar, 1000)" or as a value in a matrix.

Knowledge Levels…

- **Brachman's 5 levels of knowledge:**

  o **Implementational Level**

    ▪ The primitives are pointers and memory cells. It allows the construction of data structures with no a priori semantics.

  o **Logical Level**

    ▪ The primitives are logical predicates, operators, and propositions.

  o **Epistemological Level**

    ▪ The primitives are concept types and structuring relations that provide structure in a network of conceptual types or units. It deals with the nature of knowledge and how it relates to such concepts as truth, belief, and justification.

  o **Conceptual Level**

    ▪ The primitives are conceptual relations, primitive objects and actions.

  o **Linguistic Level**

    ▪ The primitives are words, and (linguistic) expressions. The primitives are associated directly to nouns and verbs of a specific natural language.

Knowledge Base

- A Knowledge Base (KB) is a software which captures human knowledge, converts it into a machine-readable form and uses this knowledge to solve problems which only human could solve. It is a well-organized database which allows the user to perform semantic and logical operations.

- A knowledge base is an integral part of any knowledge-based intelligent system. It maps objects and relationships of the real world to computational objects and relationships, as shown in the following figure.
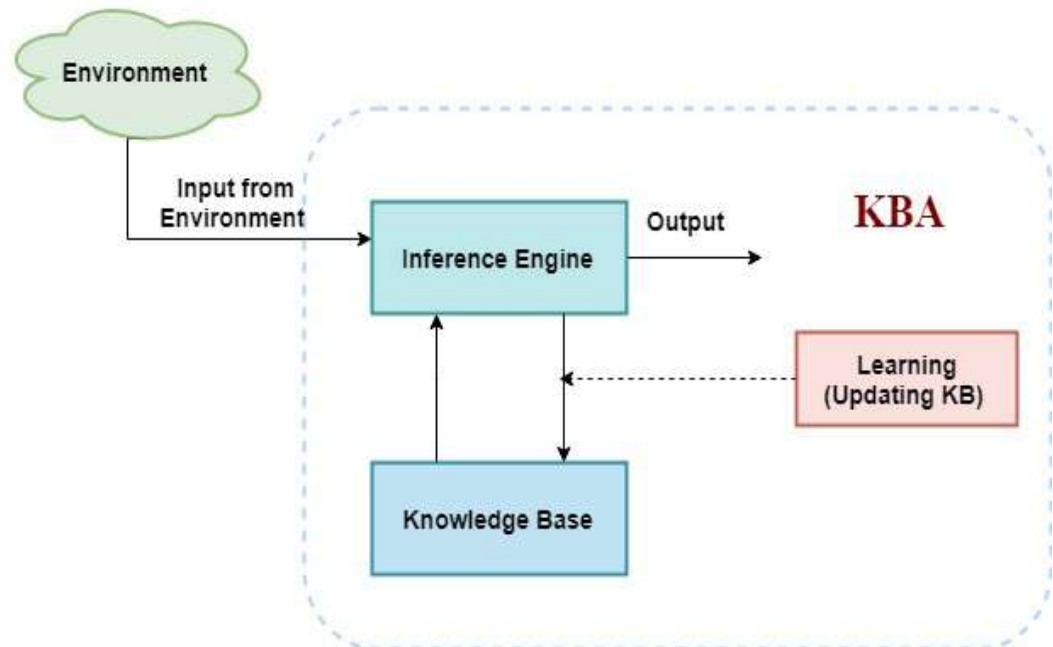
Knowledge Base & Knowledge Management

- The efficiency of a Knowledge base highly depends on how the system manages the knowledge. Hence, a range of strategies known as Knowledge management which enables you to create, curate, share and manage knowledge across the whole company is the crucial factor for a Knowledge base .

- Knowledge management focuses on improving self-service, i.e., a person tries to find information by themselves without other person's help. It is a planned and integral part of continuous improvement.
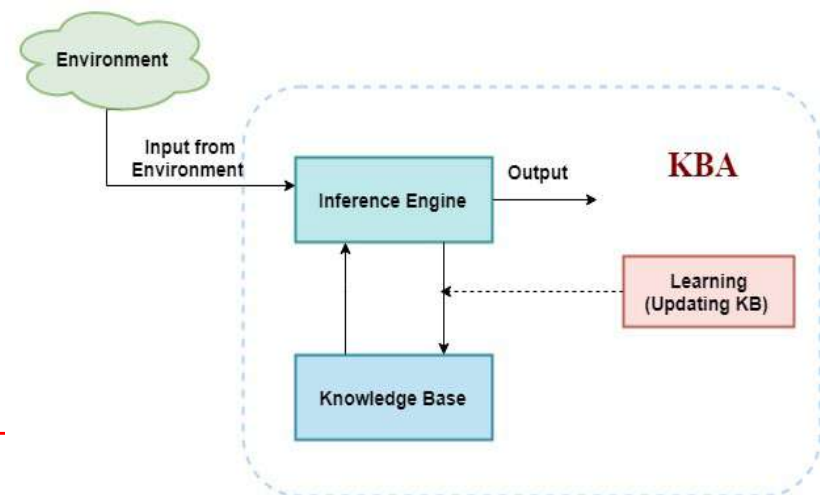
Knowledge-based Agent…

- An intelligent agent needs **knowledge** about the real world for taking decisions and reasoning to act efficiently. Knowledge-based agents are those agents who have **the capability of maintaining an internal state of knowledge, reason over that knowledge, update their knowledge after observations and take actions**.

- These agents can represent the world with **some formal representation and act intelligently**. Knowledge-based agents are composed of two main parts:
  - **Knowledge-base** and
  - **Inference system**.

The figure is a generalized architecture for a knowledge-based agent. The knowledge-based agent (KBA) take input from the environment by perceiving the environment. The input is taken by the inference engine of the agent and which also communicate with KB to decide as per the knowledge store in KB. The learning element of KBA regularly updates the KB by learning new knowledge.

Knowledge-based Agent…

- **Knowledge base:**
  - Knowledge-base is a central component of a knowledge-based agent, it is also known as KB. It is a collection of sentences that are expressed in a language which is called a knowledge representation language.
  - The Knowledge-base of KBA stores fact about the world and it is required for updating knowledge for an agent to learn with experiences and take action as per the knowledge.

- **Inference engine:**
  - Inference means deriving new sentences from old. Inference system allows us to add a new sentence to the knowledge base. It applies logical rules to the KB to deduce new information/facts from known ones or to answer a variety of KB queries. Inference system generates new facts so that an agent can update the KB.

Knowledge-based Agent

- **Operations Performed by a generic KBA**
  - o Following are three operations which are performed by KBA in order to show the intelligent behavior:
    - ▪ **TELL:** This operation tells the knowledge base what it perceives from the environment.
    - ▪ **ASK:** This operation asks the knowledge base what action it should perform.
    - ▪ **Perform:** It performs the selected action.
  - o The knowledge-based agent takes percept as input and returns an action as output. The agent maintains the knowledge base, KB, and it initially has some background knowledge of the real world. It also has a counter to indicate the time for the whole process, and this counter is initialized with zero.

The structure outline of a generic knowledge-based agents program:

```
function KB-AGENT(percept):
persistent: KB, a knowledge base
        t, a counter, initially 0, indicating time
TELL(KB, MAKE-PERCEPT-SENTENCE(percept, t))
Action = ASK(KB, MAKE-ACTION-QUERY(t))
TELL(KB, MAKE-ACTION-SENTENCE(action, t))
t = t + 1
return action
```

- ▪ The **MAKE-PERCEPT-SENTENCE** generates a sentence as setting that the agent perceived the given percept at the given time.
- ▪ The **MAKE-ACTION-QUERY** generates a sentence to ask which action should be done at the current time.
- ▪ The **MAKE-ACTION-SENTENCE** generates a sentence which asserts that the chosen action was executed.

Database vs Knowledge Base

- **Is knowledge base same as a database?**

    o A database is an organized body of related information. It behaves like an adequate storeroom in which can store all things in the house. It can store everything and will give everything it has on the matter, and one has to search what he/she wants within the massive pile of data. Inventory systems, and library software etc., are examples of databases.

    o Knowledge base on the other hand, is precise, like getting an expert opinion on a specific problem or a query. It is smarter than a database and has a logic behind all of the data it contains and understands the rationale behind each question and provides only the relevant results. In short, Knowledge base gives easy access to accurate and consistent information.

Applications of Knowledge Base

- In 1980's Knowledge base systems were first used in Expert systems were among the first truly successful forms of artificial intelligence (AI) software. Since then, they have been applied in various fields and platforms.

- A major change in their application was brought by the Internet. With the rise of the Internet, documents, hypertext, and multimedia support were critical for corporate databases. They are mainly applied in Knowledge application technologies which include:

  o expert systems

  o decision support systems

  o advisor systems

  o fault diagnosis (or troubleshooting) systems

  o help desk systems.

Knowledge Representation

TO BE CONTINUED…