Artificial Intelligence

Engr. Madeha Mushtaq
Department of Computer Science
Iqra National University

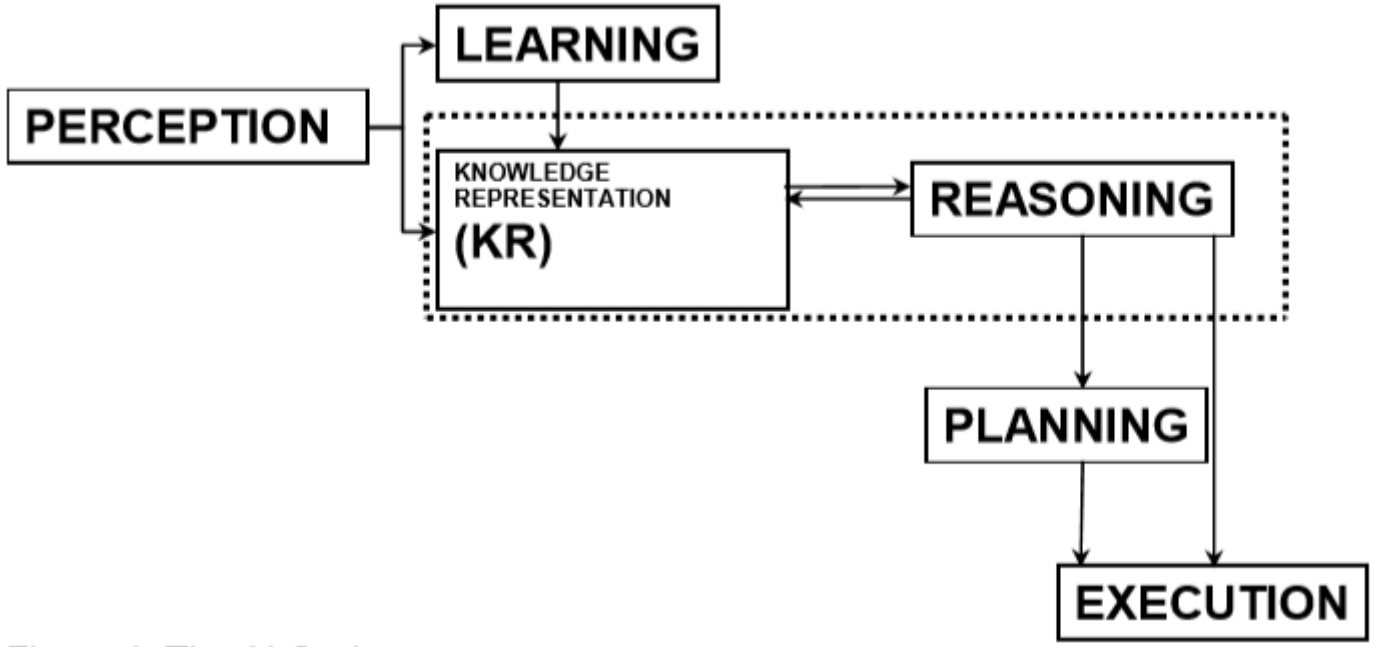
Knowledge Representation and Reasoning

- We have looked at general problem solving.
- Lets look at knowledge representation and reasoning which are important aspects of any artificial intelligence system and of any computer system.

The AI Cycle

- Almost all AI systems have the following components in general:
  - Perception
  - Learning
  - Knowledge Representation and Reasoning
  - Planning
  - Execution
- Figure next shows the relationship between these components.

The AI Cycle


LEARNING
PERCEPTION
KNOWLEDGE
REPRESENTATION
(KR)
REASONING
PLANNING
EXECUTION

The AI Cycle

- An AI system has a perception component that allows the system to get information from its environment.
- As with human perception, this may be visual, audio or other forms of sensory information.
- The system must then form a meaningful and useful representation of this information internally.
- This knowledge representation maybe static or it may be coupled with a learning component that is adaptive and draws trends from the perceived data.

The AI Cycle

- Knowledge representation (KR) and reasoning are closely coupled components; each is intrinsically tied to the other.
- A representation scheme is not meaningful on its own; it must be useful and helpful in achieving certain tasks.
- The same information may be represented in many different ways, depending on how you want to use that information.

The AI Cycle

- For example, in mathematics, if we want to solve problems about ratios, we would most likely use algebra, but we could also use simple hand drawn symbols.
- To say half of something, you could use 0.5x or you could draw a picture of the object with half of it coloured differently.
- Both would convey the same information but the former is more compact and useful in complex scenarios where you want to perform reasoning on the information.
- It is important at this point to understand how knowledge representation and reasoning are interdependent components.

The Dilemma

- The key question is how to approach the problem.
- Should we try to emulate the human brain completely and exactly as it is?
- Or should we come up with something new?
- Since we do not know how the KR and reasoning components are implemented in humans, even though we can see their manifestation in the form of intelligent behaviour, we need a synthetic (artificial) way to model the knowledge representation and reasoning capability of humans in computers.

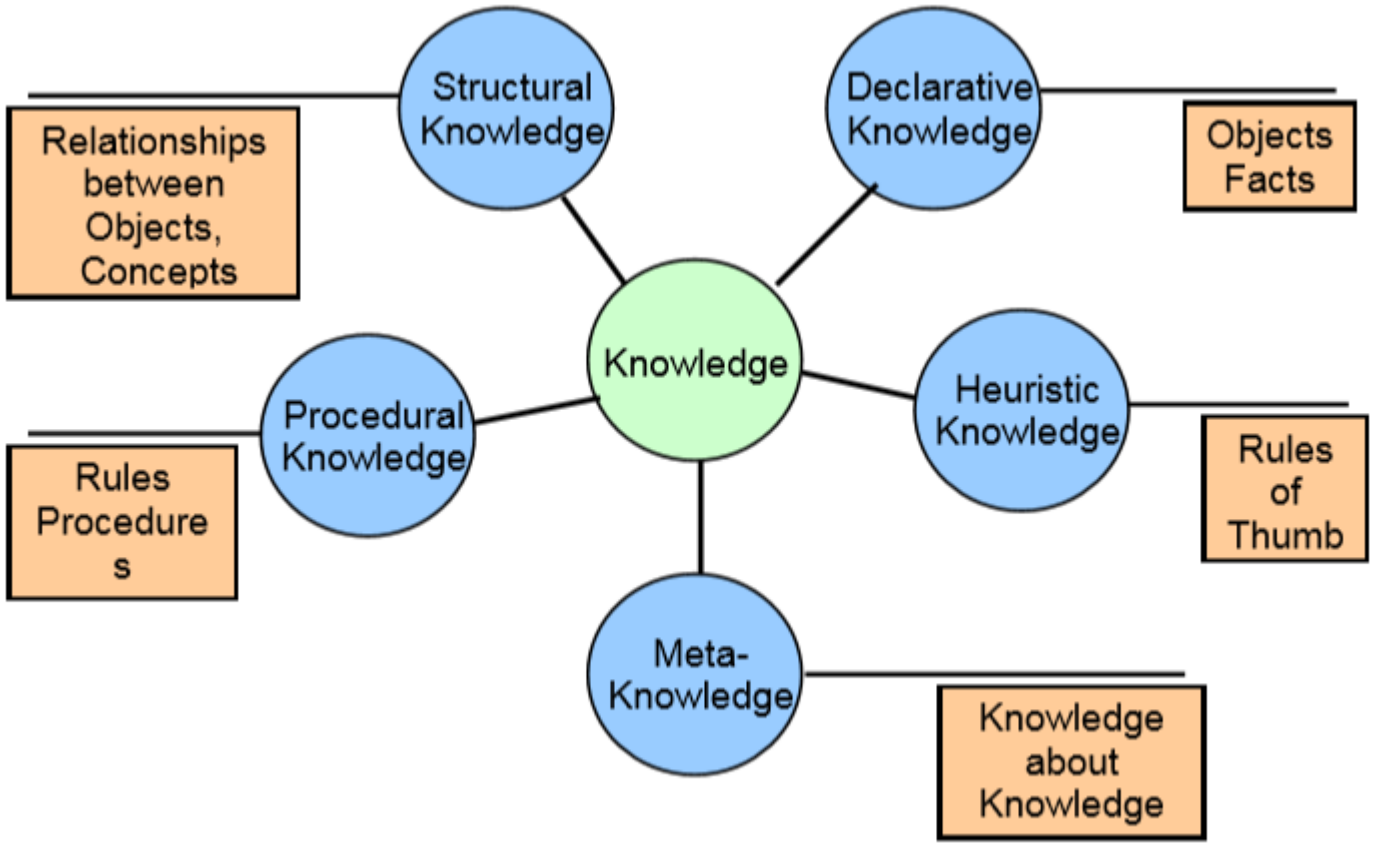
Knowledge and its types

- What is knowledge? Durkin refers to it as the “Understanding of a subject area”.
- A well-focused subject area is referred to as a knowledge domain, for example, medical domain, engineering domain, business domain, etc..
- If we analyze the various types of knowledge we use in every day life, we can broadly define knowledge to be one of the following categories:
- **Procedural knowledge:** Describes how to do things, provides a set of directions of how to perform certain tasks, e.g., how to drive a car.
- **Declarative knowledge:** It describes objects, rather than processes. What is known about a situation, e.g. it is sunny today, and cherries are red.

Knowledge and its types

- **Meta knowledge:** Knowledge about knowledge, e.g., the knowledge that blood pressure is more important for diagnosing a medical condition than eye color.
- **Heuristic knowledge:** Rule-of-thumb, e.g. if I start seeing shops, I am close to the market. Heuristic knowledge is sometimes called shallow knowledge.
- **Structural knowledge:** Describes structures and their relationships. e.g. how the various parts of the car fit together to make a car, or knowledge structures in terms of concepts, sub concepts, and objects.

Knowledge and its types



Knowledge Representation (KR)

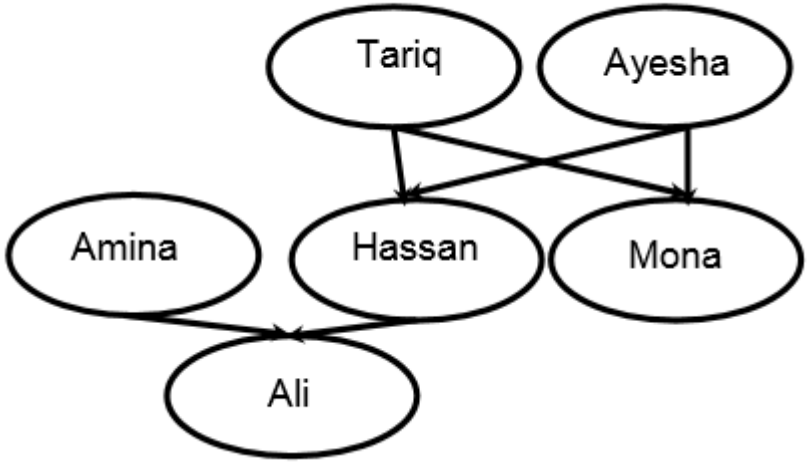
- There are multiple approaches and schemes that come to mind when we begin to think about representation.
- **Pictures and symbols:** This is how the earliest humans represented knowledge when sophisticated linguistic systems had not yet evolved.
- **Graphs and Networks**
- **Numbers**

Knowledge Representation

- **Pictures:**
- Each type of representation has its benefits. What types of knowledge is best represented using pictures?
- We could use a series of pictures to store procedural knowledge, e.g. how to boil an egg.
- We can easily see that pictures are best suited for recognition tasks and for representing structural information.
- However, pictorial representations are not very easily translated to useful information in computers.
- So even though pictures are useful for human understanding, because they provide a high level view of a concept to be obtained readily, using them for representation in computers is not as straight forward.

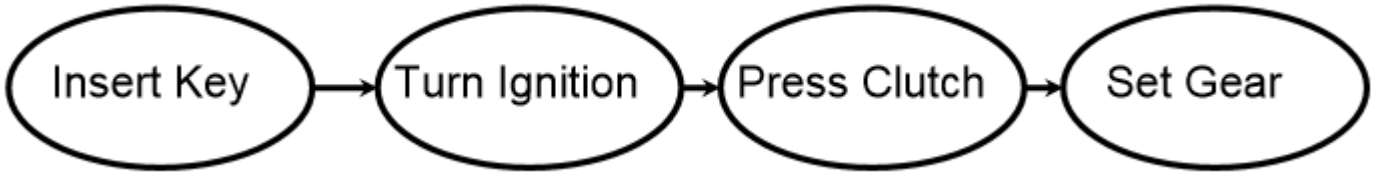
Knowledge Representation

- **Graphs and Networks:**
- Graphs and Networks allow relationships between objects/entities to be incorporated, e.g., to show family relationships, we can use a graph.



Knowledge Representation

- **Graphs and Networks:**
- We can also represent procedural knowledge using graphs, e.g. How to start a car?



Knowledge Representation

- **Numbers:**
- Numbers are an integral part of knowledge representation used by humans.
- Numbers translate easily to computer representation.
- Eventually, as we know, every representation we use gets translated to numbers in the computers internal representation.

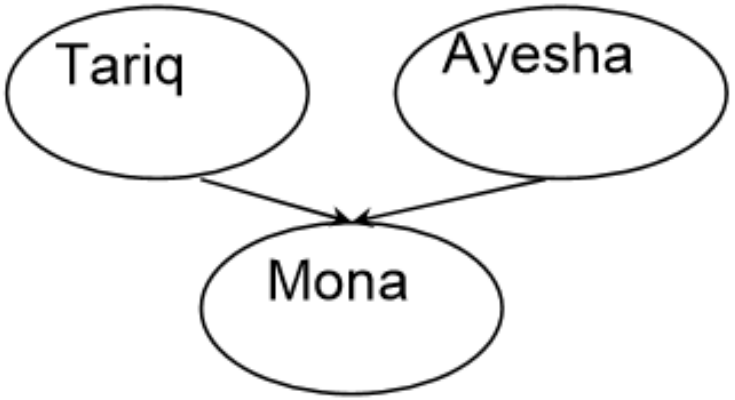
Knowledge Representation

- As an example, let's look at some ways to represent the knowledge of a family.
- **Using a picture:**

- This kind of representation makes sense readily to humans, but not to computers.
- Computers need complex computer vision algorithms to understand pictures.

Knowledge Representation

- **Using a graph:**



- This representation is more direct and highlights relationships.

Knowledge Representation (KR)

- **Using a description in words:**
- For the family above, we could say in words – Tariq is Mona's Father – Ayesha is Mona's Mother – Mona is Tariq and Ayesha's Daughter.
- This example demonstrates the fact that each knowledge representation scheme has its own strengths and weaknesses.

Formal KR techniques

- In the examples above, we explored intuitive ways for knowledge representation.
- Now, we will turn our attention to formal KR techniques in AI.
- While studying these techniques, it is important to remember that each method is suited to representing a certain type of knowledge.
- Choosing the proper representation is important because it must help in reasoning.
- As the saying goes ‘Knowledge is Power’.

Facts

- Facts are a basic block of knowledge (the atomic units of knowledge).
- They represent declarative knowledge (they declare knowledge about objects).
- A proposition is the statement of a fact.
- Each proposition has an associated truth value. It may be either true or false.
- In AI, to represent a fact, we use a proposition and its associated truth value, e.g.
- –Proposition A: It is raining, – Proposition B: I have an umbrella, – Proposition C: I will go to school.

Types of Facts

- **Single-valued or multiple –valued**
- Facts may be single-valued or multi-valued, where each fact (attribute) can take one or more than one values at the same time, e.g. an individual can only have one eye color, but may have many cars. So the value of attribute cars may contain more than one value.
- **Uncertain facts**
- Sometimes we need to represent uncertain information in facts. These facts are called uncertain facts, e.g. it will probably be sunny today. We may chose to store numerical certainty values with such facts that tell us how much uncertainty there is in the fact.

Types of facts

- **Fuzzy facts**
- Fuzzy facts are ambiguous in nature, e.g. the book is heavy/light. Here it is unclear what heavy means because it is a subjective description. Fuzzy representation is used for such facts. While defining fuzzy facts, we use certainty factor values to specify value of “truth”.
- **Object-Attribute-Value triplets**
- Object-Attribute Value Triplets or OAV triplets are a type of fact composed of three parts; object, attribute and value. Such facts are used to assert a particular property of some object. For example:
- Ali’s eye color is brown.
- Object: Ali, Attribute: eye color, Value: brown

Rules

- Rules are another form of knowledge representation.
- Durkin defines a rule as “A knowledge structure that relates some known information to other information that can be concluded or inferred to be true.”

Components of a Rule

- A Rule consists of two components
  - Antecedent or premise or the IF part
  - Consequent or conclusion or the THEN part
- For example, we have a rule: IF it is raining THEN I will not go to school
  - Premise: It is raining
  - Conclusion: I will not go to school.

Compound Rules

- Multiple premises or antecedents may be joined using AND (conjunctions) and OR (disjunctions), e.g.
- IF it is raining AND I have an umbrella THEN I will go to school.
- IF it is raining OR it is snowing THEN I will not go to school

Types of Rules

- **Relationship**
- Relationship rules are used to express a direct occurrence relationship between two events, e.g. IF you hear a loud sound THEN the silencer is not working
- **Recommendation**
- Recommendation rules offer a recommendation on the basis of some known information, e.g. IF it is raining THEN bring an umbrella.

Types of Rules

- **Directive:**
- Directive rules are like recommendations rule but they offer a specific line of action, as opposed to the ‘advice’ of a recommendation rule, e.g.
- IF it is raining AND you don’t have an umbrella THEN wait for the rain to stop.
- **Variable Rules:**
- If the same type of rule is to be applied to multiple objects, we use variable rules, i.e. rules with variables, e.g.
- If X is a Student AND X’s GPA>3.7 THEN place X on honor roll.
- Such rules are called pattern-matching rules.
- The rule is matched with known facts and different possibilities for the variables are tested, to determine the truth of the fact.

Types of Rules

- **Uncertain Rules:**
- Uncertain rules introduce uncertain facts into the system, e.g. IF you have never won a match THEN you will most probably not win this time.
- **Meta Rules:**
- Meta rules describe how to use other rules, e.g. IF you are coughing AND you have chest congestion THEN use the set of respiratory disease rules.
- **Rule Sets:**
- As in the previous example, we may group rules into categories in our knowledge representation scheme, e.g. the set of respiratory disease rules

End of Slides