VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE | DEPARTMENT OF COMPUTER SCIENCE

Fundamentals of Machine Learning

Knowledge Representation

Jan Platos

November 25, 2025

Knowledge Representation

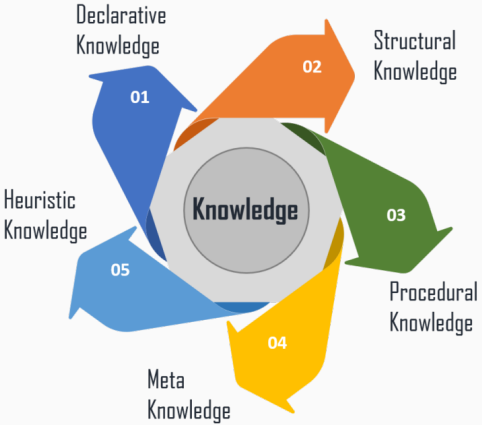
Knowledge Representation

- Knowledge Representation describes how the beliefs, intentions and judgments of an intelligence agent can be expressed for automated reasoning.
- 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 - Knowledge

- The different kinds of knowledge that need to be represented in AI include:
  - Objects
  - Events
  - Performance
  - Facts
  - Meta-Knowledge
  - Knowledge-base

Knowledge Representation - Knowledge



https://www.edureka.co/blog/knowledge-representation-in-ai/

Knowledge Representation - Knowledge

- 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.
- 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.

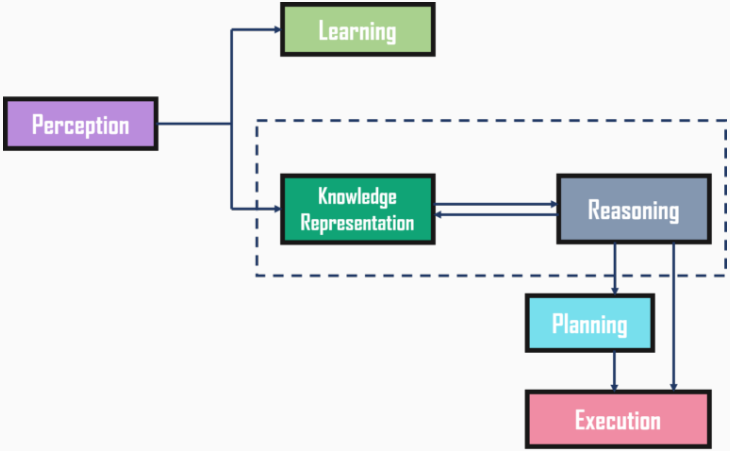
Knowledge Representation - Knowledge

- 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.

Knowledge Representation - Knowledge

- Meta Knowledge
  - Knowledge about other types of Knowledge.
- 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.

Knowledge Representation - Cycle



https://www.edureka.co/blog/knowledge-representation-in-ai/

Knowledge Representation - Cycle

- **Perception** – retrieves data or information from the environment. It is able to identify noise the validity of the data.
- **Learning** – learns from the collected data. In order to learn new things, the system requires knowledge acquisition, inference, acquisition of heuristics, faster searches, etc.
- **Knowledge representation and reasoning** – s all about understanding intelligence. nstead of trying to understand or build brains from the bottom up, its goal is to understand and build intelligent behavior from the top-down and focus on what an agent needs to know in order to behave intelligently.

Knowledge Representation - Cycle

- **Planning and Execution** depend on the analysis of knowledge representation and reasoning. Planning includes giving an initial state, finding their preconditions and effects, and a sequence of actions to achieve a state in which a particular goal holds. Now once the planning is completed, the final stage is the execution of the entire process.

Knowledge Representation - Techniques

https://www.edureka.co/blog/knowledge-representation-in-ai/

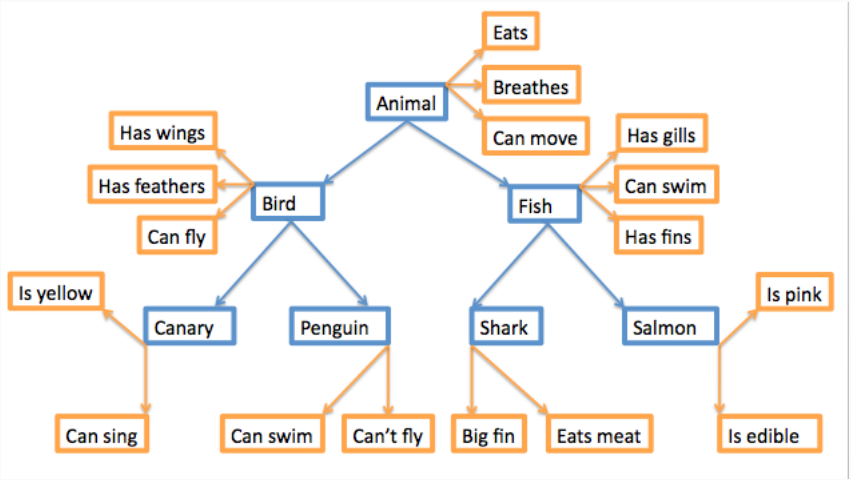
Knowledge Representation - Techniques - Logical representation

- Logical representation is a language with some concrete rules which deals with propositions and has no ambiguity in representation.
- Logical representation means drawing a conclusion based on various conditions.
- This representation lays down some important communication rules.
- It consists of precisely defined *syntax* and *semantics* which supports the sound inference.
- Each sentence can be translated into logic using syntax and semantics.

Knowledge Representation - Techniques - Semantic Network

- Semantic networks are alternative of predicate logic for knowledge representation.
- 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.
- Semantic networks can categorize the object in different forms and can also link those objects.
- Semantic networks are easy to understand and can be easily extended.

Knowledge Representation - Techniques - Semantic Network



Knowledge Representation - Techniques - Frame

- A frame is a record like structure which consists of a collection of attributes and its values to describe an entity in the world.
- Frames are the AI data structure which divides knowledge into substructures by representing stereotypes situations.
- It consists of a collection of slots and slot values.
- These slots may be of any type and sizes.
- Slots have names and values which are called facets.

Knowledge Representation - Techniques - Production Rules

- Production rules system consist of (condition, action) pairs which mean, ”If condition then action”.
- It has mainly three parts:
  - The set of production rules
  - Working Memory
  - The recognize-act-cycle
- The condition part of the rule determines which rule may be applied to a problem.
- The action part carries out the associated problem-solving steps.
- This complete process is called a recognize-act cycle.

Knowledge Representation - Techniques - Production Rules

- The working memory contains the description of the current state of problems-solving and rule can write knowledge to the working memory.
- This knowledge match and may fire other rules.
- If there is a new situation (state) generates, then multiple production rules will be fired together, this is called conflict set.
- In this situation, the agent needs to select a rule from these sets, and it is called a conflict resolution.

Knowledge Representation - Requirements

- Representational Accuracy: It should represent all kinds of required knowledge.
- Inferential Adequacy: It should be able to manipulate the representational structures to produce new knowledge corresponding to the existing structure.
- Inferential Efficiency: The ability to direct the inferential knowledge mechanism into the most productive directions by storing appropriate guides.
- Acquisitional efficiency: The ability to acquire new knowledge easily using automatic methods.

Knowledge Representation - Machine Learning

- Machine learning is simplified system and requires different representation.
- Knowledge is learned according to the chosen algorithm.
- Each algorithm uses specific knowledge representation and specific concepts.
- Most algorithms expects vector representations.

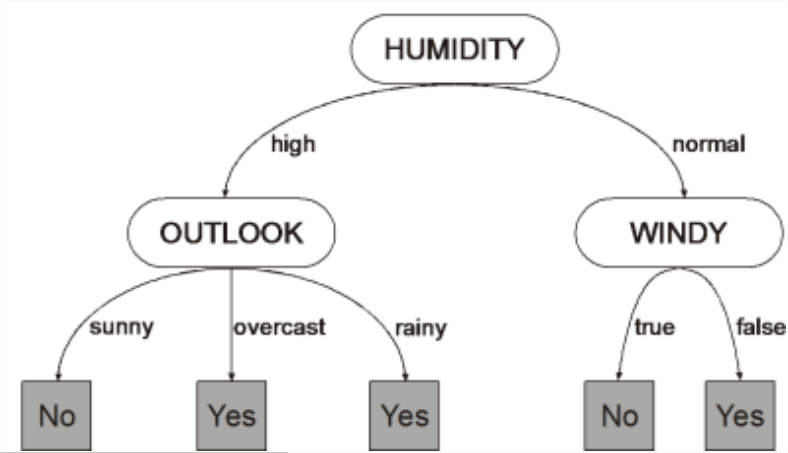
Knowledge Representation - Decision Table

Play golf dataset

Independent variables				Dep. var
OUTLOOK	TEMPERATURE	HUMIDITY	WINDY	PLAY
sunny	85	85	FALSE	Don't Play
sunny	80	90	TRUE	Don't Play
overcast	83	78	FALSE	Play
rain	70	96	FALSE	Play
rain	68	80	FALSE	Play
rain	65	70	TRUE	Don't Play
overcast	64	65	TRUE	Play
sunny	72	95	FALSE	Don't Play
sunny	69	70	FALSE	Play
rain	75	80	FALSE	Play
sunny	75	70	TRUE	Play
overcast	72	90	TRUE	Play
overcast	81	75	FALSE	Play
rain	71	80	TRUE	Don't Play

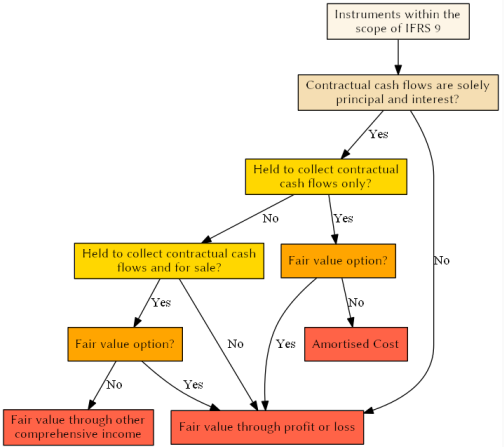
https://medium.datadriveninvestor.com/5-main-types-of-knowledge-representation-in-machine-learning-5aebcbeeff42

Knowledge Representation - Decision Tree



https://medium.datadriveninvestor.com/5-main-types-of-knowledge-representation-in-machine-learning-5aebcbeeff42

Knowledge Representation - Classification rule



https://medium.datadriveninvestor.com/5-main-types-of-knowledge-representation-in-machine-learning-5aebcbeeff42

Knowledge Representation - Association rule

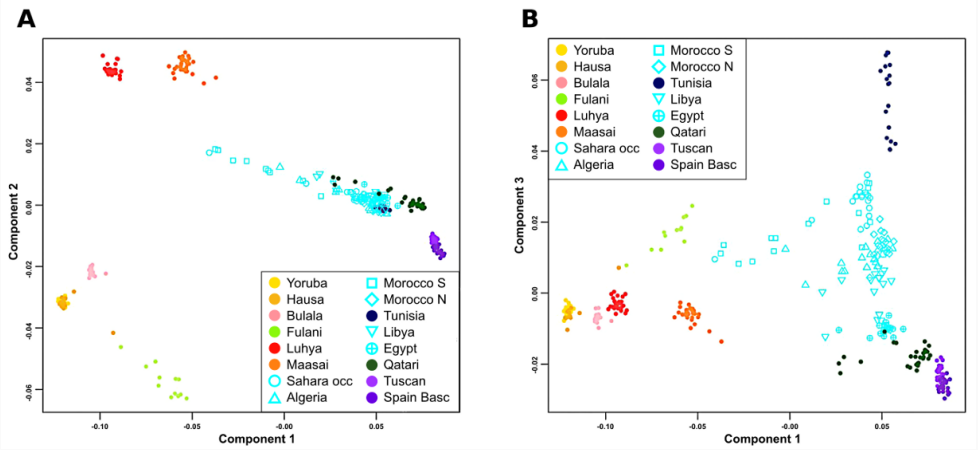
- Generalization of the Classification Rule
- May predict any type of attribute.
- May prediction multiple attributes or combinations.
- Rules may be combined to gather the knowledge

$$\textbf{If } \textit{temperature} = \textit{cool} \textbf{ then } \textit{humidity} = \textit{normal}$$

Knowledge Representation - Rules with exceptions

- Generalization of any rules using exceptions.
- Naturally adapts a rules set using the exception.
- Exceptions may be explained by domain expert.

Knowledge Representation - Clusters



https://medium.datadriveninvestor.com/5-main-types-of-knowledge-representation-in-machine-learning-5aebcbeeff42

Questions