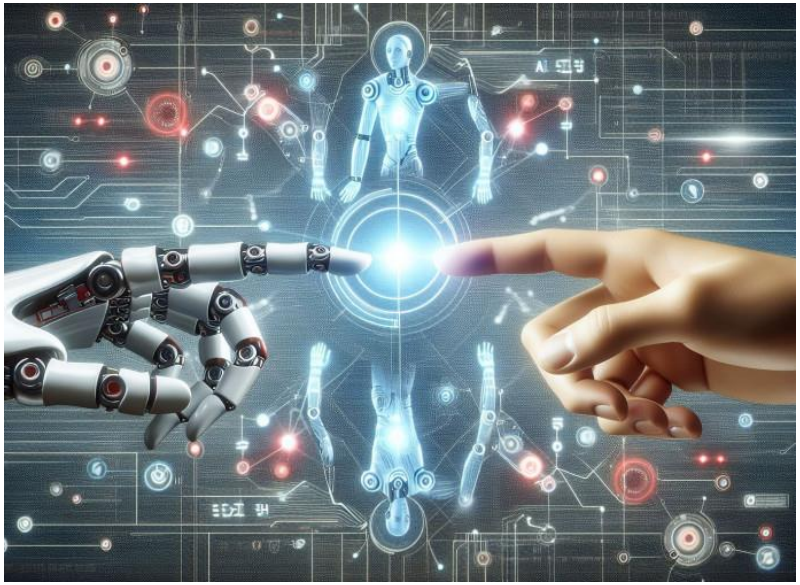
Lecture 3

Expert systems



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Knowledge Representation

Knowledge Representation

- **Knowledge representation** is the process of encoding human knowledge and reasoning into a symbolic language that a computer can use to solve complex problems.
- **How is Knowledge Used?**

Problem Solving: Applying knowledge to find solutions to challenges

Decision Making: Using knowledge to make informed choices

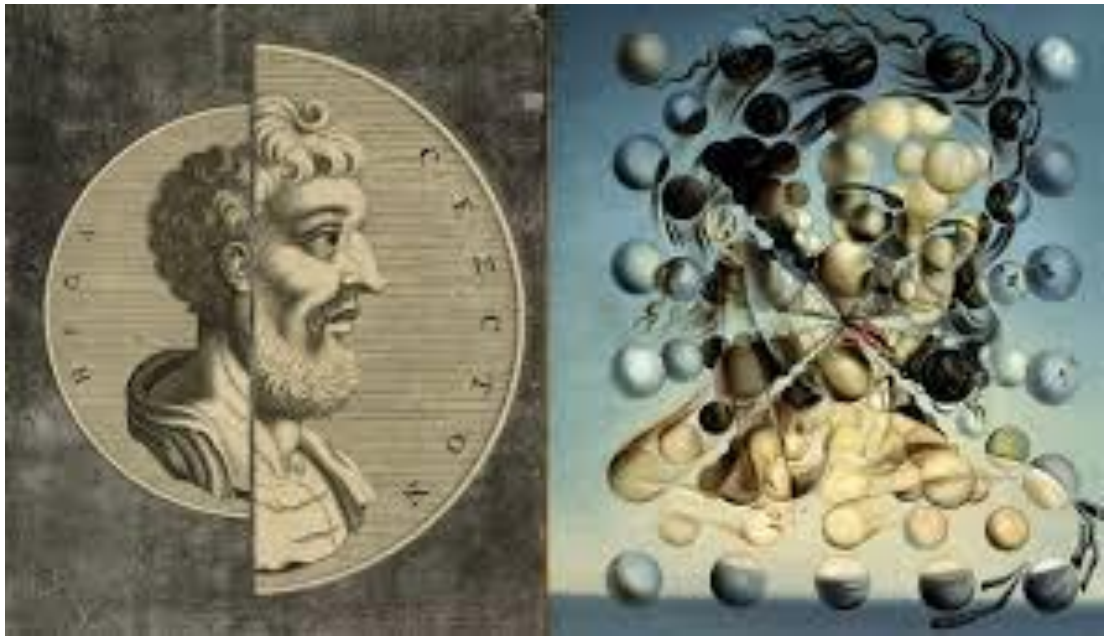
Communication: Sharing and exchanging information with others

Prediction: Using knowledge to anticipate future events

Reasoning: Drawing conclusions from known facts

Epistemology

علم المعرفة الفلسفية



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Epistemology

- **Definition**:

the branch of philosophy concerned with the theory of knowledge, which studies the nature, origin, and scope of knowledge.

It explores fundamental questions about

What is knowledge?
How do we acquire knowledge?
What makes knowledge valid or true?
What are the limits of human knowledge?

Importance: Understanding epistemology helps us better represent and use knowledge in AI systems

Categories of Epistemology

Knowledge can be classified in several ways:

1. **A Priori vs A Posteriori**
   Based on how knowledge is acquired
2. **Procedural vs Declarative**
   Based on the type of knowledge
3. **Tacit vs Explicit**
   Based on how knowledge is expressed

A Priori Knowledge (المعرفة المستقلة عن التجربة)

A priori knowledge is knowledge that is **independent** of sensory experience or empirical evidence; known through reasoning alone.

Characteristics:

- Does not require empirical evidence
- Known through logic and reason

Examples:

- Mathematical truths: 2 + 2 = 4
- Geometric principles: "A triangle has three sides"
- "If A is bigger than B, and B is bigger than C, then A is bigger than C"

A Posteriori Knowledge (المعرفة التجريبية)

A posteriori knowledge is knowledge that **depends** on experience or empirical evidence.

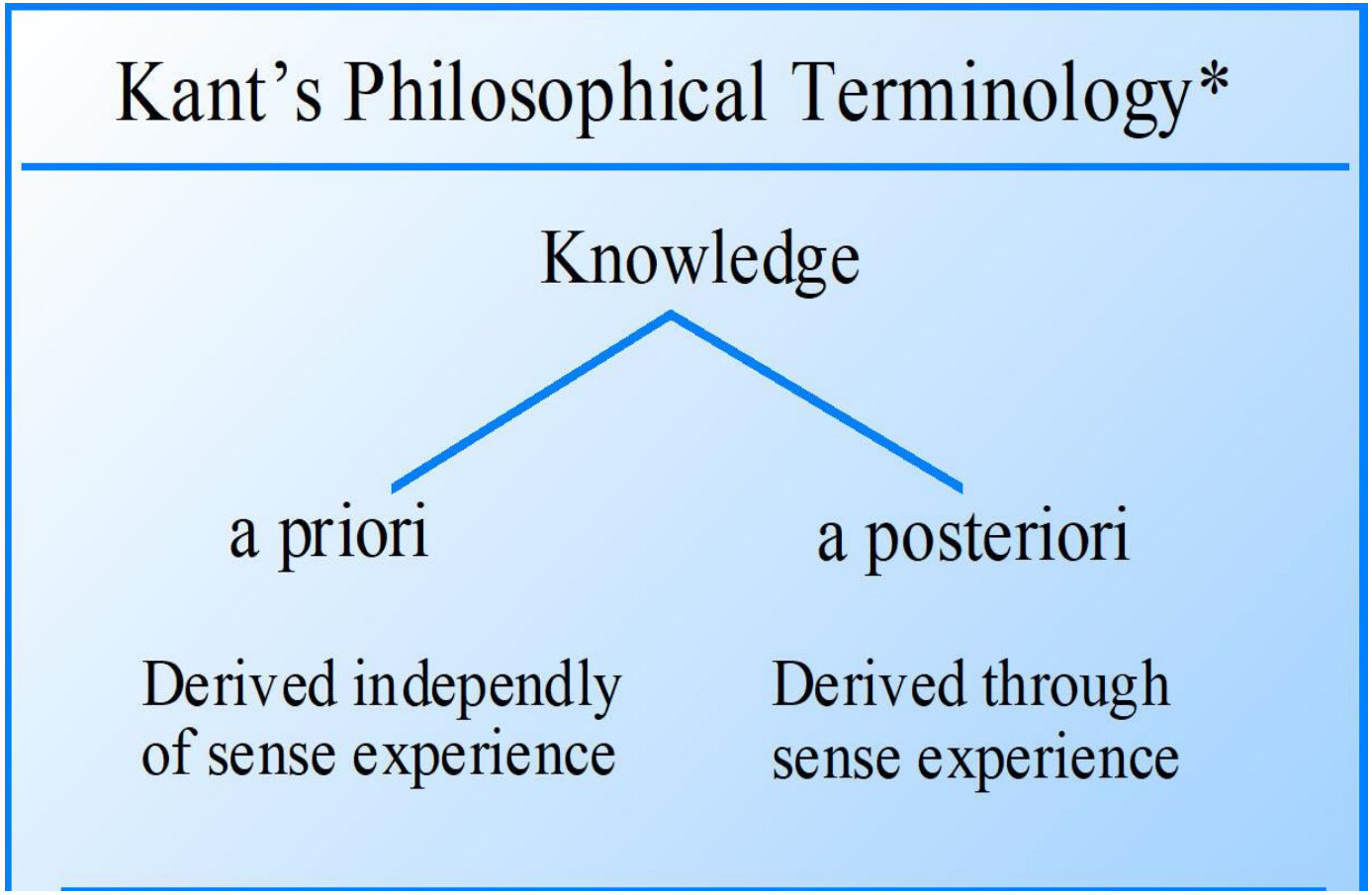
Characteristics:

- Acquired through observation and experience
- Can be verified through experimentation

Examples:

- "Water boils at 100°C "
- "The sky is blue"

Summery


Kant's Philosophical Terminology*
Knowledge
a priori
a posteriori
Derived independly of sense experience
Derived through sense experience

Procedural Knowledge (المعرفة الإجرائية)

Definition: Knowledge of "**how**" to do something. It's the knowledge of steps and procedures.

Characteristics:

- Often difficult to express in words
- Learned through practice and repetition

Examples:

- How to ride a bicycle
- How to swim

Declarative Knowledge (المعرفة التصريحية)

Definition: Knowledge about FACTS and THINGS; knowledge that **can be stated.**

Characteristics:

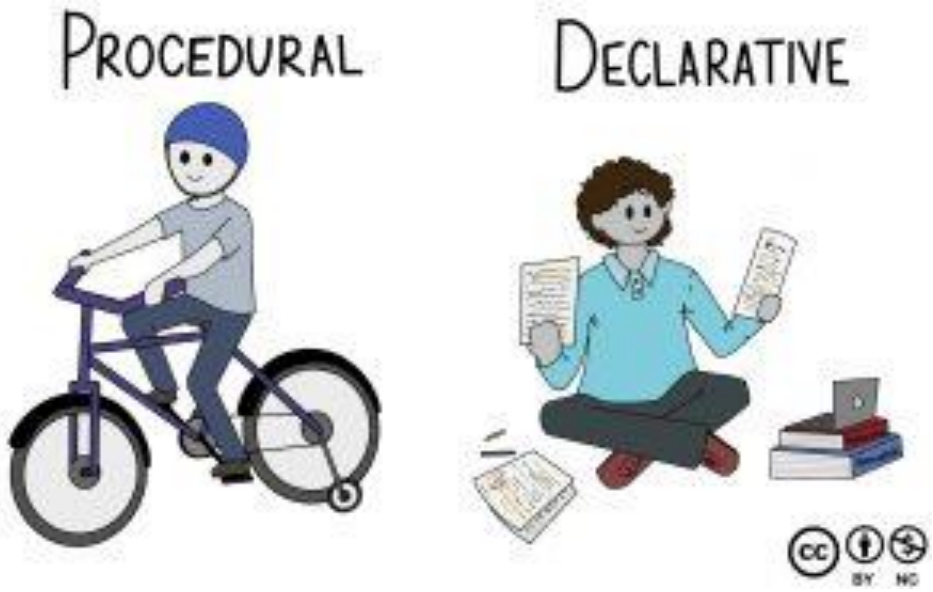
- Can be easily expressed in words
- "Knowing that" something is true

Examples:

- The Earth revolves around the Sun"
- "Cairo is in Egypt"
- "H2O is the chemical formula for water"

Summery

Declarative knowledge	•Knowing what
Procedural knowledge	•Knowing how



Tacit Knowledge (المعرفة الضمنية)

Definition: Knowledge that is **difficult to transfer** to another person by writing.

Characteristics:

- Gained through personal experience
- Hard to formalize or communicate

Examples:

The ability to identify a person's mood from their body language.

Explicit Knowledge (المعرفة المعلنة)

Explicit knowledge is information that can be easily articulated, written down, stored, and shared.

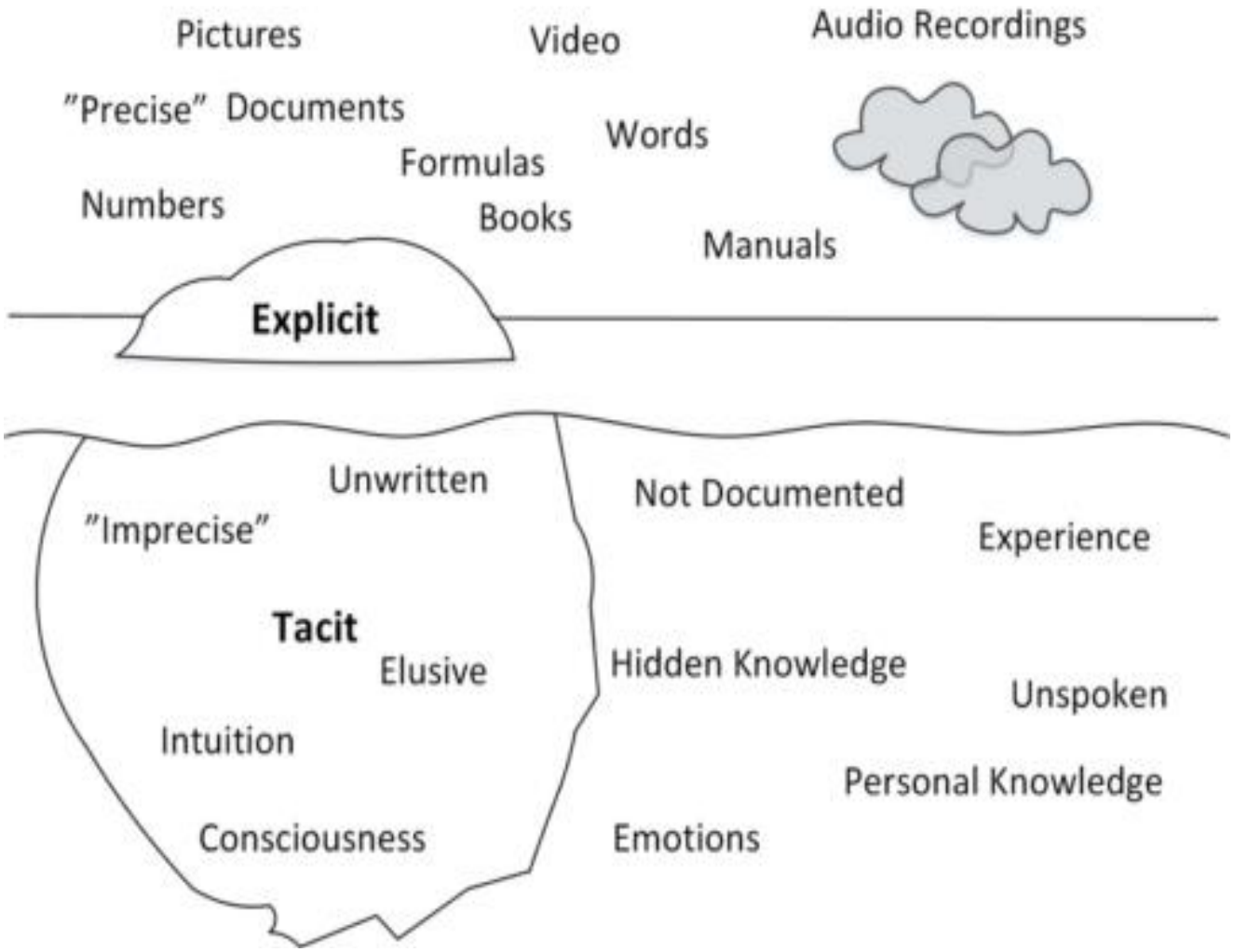
Characteristics:

- **Articulable:** Can be clearly spoken or written.
- **Easily Transferable:** Can be shared through books, files, presentations, or emails.

Examples:

- **A Scientific Formula:** $E=mc^2$
- **A Research Paper:** The published methods, results, and conclusions of an experiment.

Summery


Pictures
Video
Audio Recordings
"Precise" Documents
Words
Formulas
Numbers
Books
Manuals
Explicit
Unwritten
Not Documented
"Imprecise"
Experience
Tacit
Elusive
Hidden Knowledge
Unspoken
Intuition
Personal Knowledge
Consciousness
Emotions

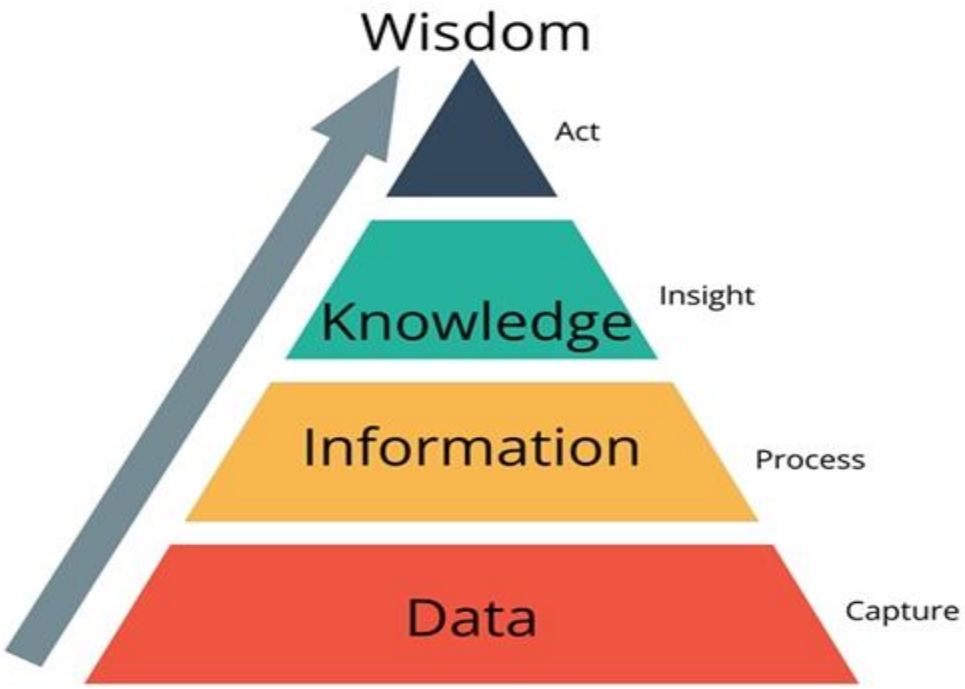
Metaknowledge ماوراء المعرفة

Definition: Knowledge about knowledge; knowing what you know and what you don't know (the limits of your knowledge)

Examples:

- Knowing *that you are an expert* in biology but a novice in economics.
- "I know that I'm good at mathematics but poor at spelling"

The Pyramid of Knowledge

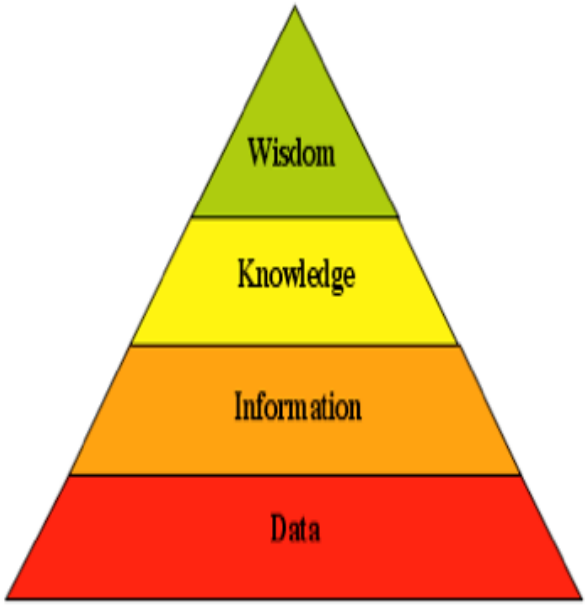


The DIKW Pyramid

The Pyramid of Knowledge

Data: Raw, unorganized facts and figures (e.g., "32°F").

Information: Data that has been processed and given context (e.g., "The temperature outside is 32°F").



Knowledge: Information that has been understood and applied (e.g., "At 32°F, water will freeze, so I should drive carefully").

Wisdom: The ability to use knowledge to make sound judgments and decisions (e.g., "Given the freezing conditions and the forecast, I will postpone my trip for safety.").

Knowledge Representation Techniques

Knowledge Representation Techniques

Knowledge representation techniques are methods used to encode and structure knowledge about the world in a format that a computer can understand and use to reason, solve problems, and make decisions.

Goal: To formalize knowledge in a way that a computer can understand and use for reasoning.

Common Techniques:

1- Productions (Rules)
2- Semantic Networks
3- Frames
4- Logic

1- Productions (Rules)

Definition: Knowledge represented as IF-THEN rules
Format: IF (condition) THEN (action/conclusion)

Examples:

IF temperature > 30°C THEN turn on air conditioning

IF student grade ≥ 90 THEN grade = "A"

IF it is raining THEN take an umbrella

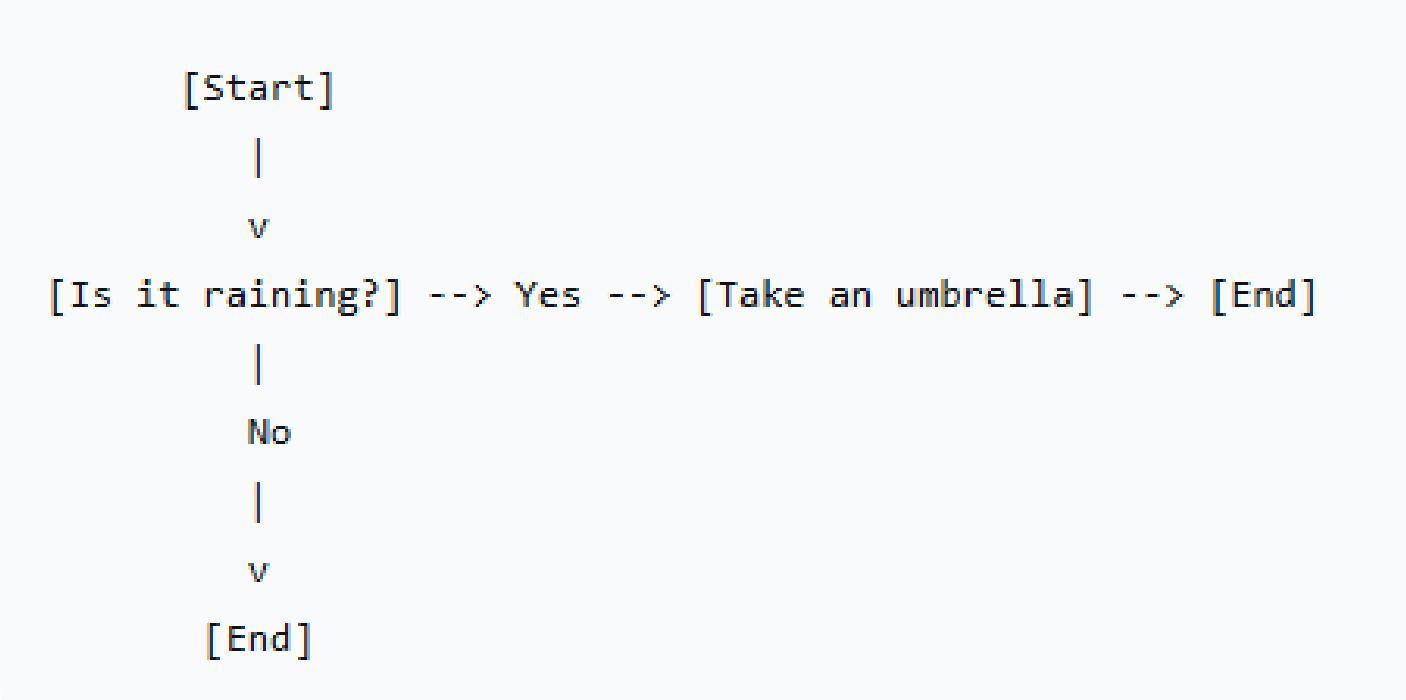
IF patient has fever AND cough THEN check for infection

Advantages: Easy to understand, modular, easy to modify

1- Productions (Rules)

Visual Example 1: Simple Daily Decision
Rule: IF it is raining THEN take an umbrella.

You can draw this as a simple flowchart:



2- Semantic Nets

Definition: A graphical representation of knowledge as a network of nodes and links.

Nodes: Represent objects, concepts, or events.
Links: Represent the relationships between the nodes.

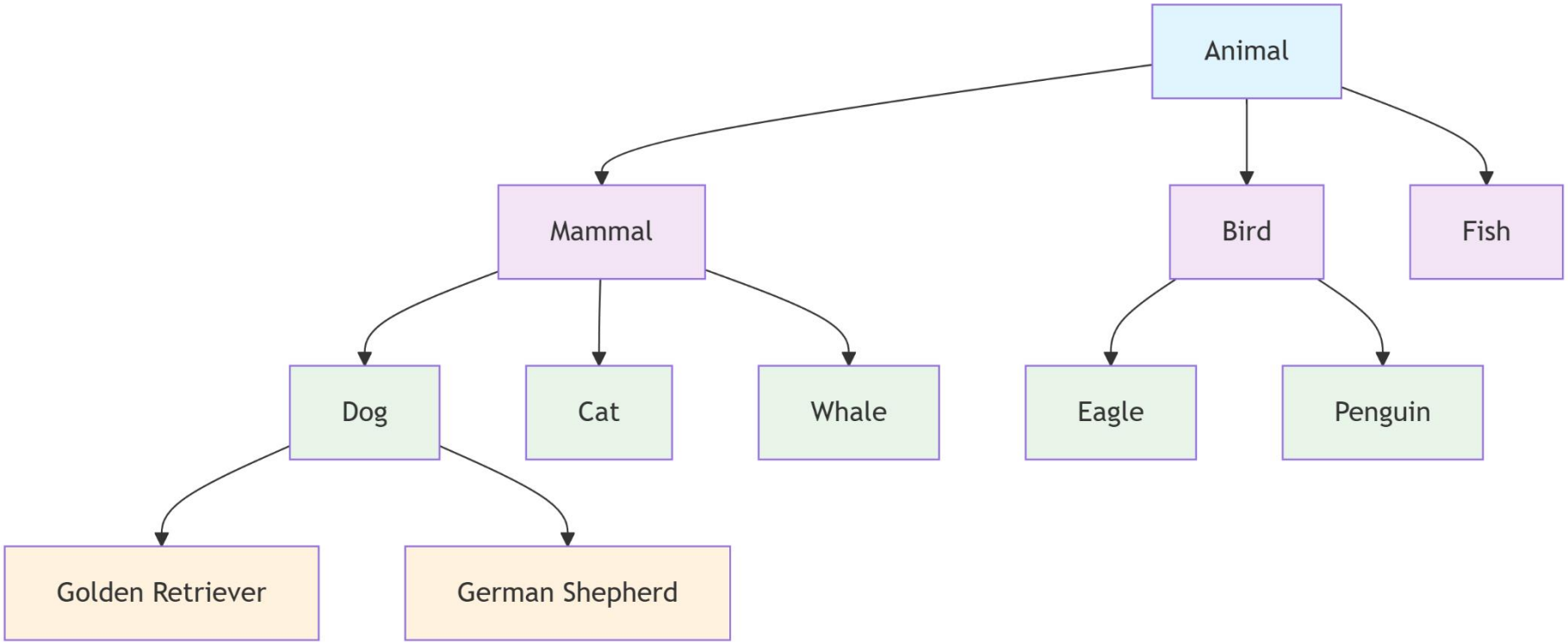
Common Types of Links

- **IS-A**: Represents class membership

Example: "Dog IS-A Animal"

- **HAS-A PART**: Represents possession or parts

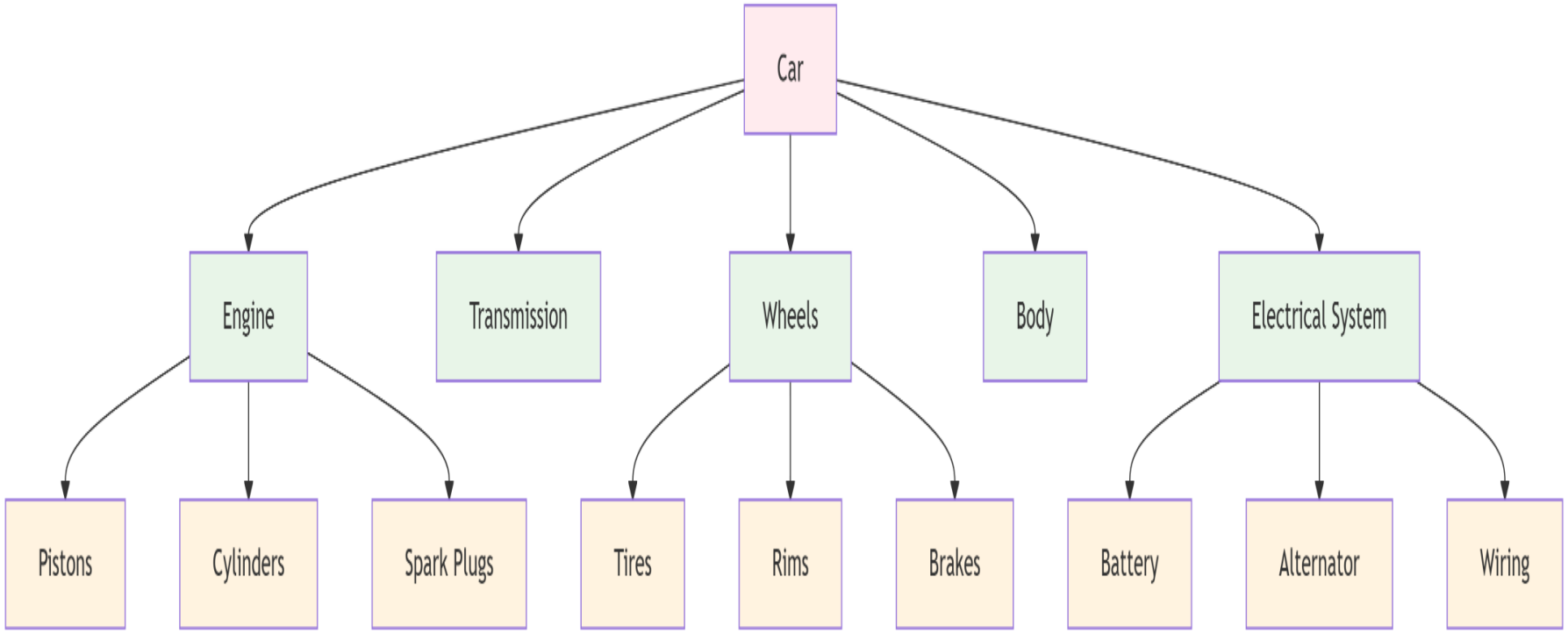
Example: "Wheel PART-OF Car"



Nodes (Concepts): Animal, Mammal, Bird, Fish, Dog, Cat, Whale, Eagle, Penguin, Golden Retriever, German Shepherd

Links (IS-A relationships):

- Dog --IS-A--> Mammal
- Mammal --IS-A--> Animal
- Golden Retriever --IS-A--> Dog
- Penguin --IS-A--> Bird
- Bird --IS-A--> Animal



Nodes (Objects/Parts):

Car, Engine, Transmission, Wheels, Body, Electrical System, Pistons, Cylinders, Spark Plugs, Tires, Rims, Brakes, Battery, Alternator, Wiring

- **Links (HAS-Part relationships):**
  - Car --HAS-Part--> Engine
  - Car --HAS-Part--> Wheels
  - Engine --HAS-Part--> Pistons
  - Wheels --HAS-Part--> Tires
  - Electrical System --HAS-Part--> Battery