

LECTURE 2

Introduction to knowledge based systems

A **knowledge-based system (KBS)** is a computer program that reasons and uses a knowledge base to solve complex problems.

The term is broad and refers to many different kinds of systems.

A knowledge-based system has two distinguishing features:

- a knowledge base
- an inference engine

Knowledge based system

- The knowledge base, represents facts about the world, often in some form of subsumption ontology/partition rule (rather than implicitly embedded in procedural code, in the way a conventional computer program does).
- Other common approaches in addition to a subsumption ontology include frames, conceptual graphs, and logical assertions.
- The inference engine, allows new knowledge to be inferred.
- Most commonly, it can take the form of IF-THEN rules coupled with forward or backward chaining approaches.
- Other approaches include the use of automated theorem provers, logic programming, e.t.c

Knowledge, what is it?

- Knowledge is body of facts and principles
- Knowledge can be language, concepts, procedures, rules, ideas, abstractions, places, customs and so on

Types of knowledge includes:

- Procedural knowledge
- Declarative knowledge
- Heuristic knowledge

Procedural knowledge

- **Procedural knowledge** is compiled or processed form of information
 - Is related to the performance of some task, for example a sequence of steps to solve a problem is procedural knowledge
 - The control information that is necessary to use knowledge is considered to be embedded in the knowledge itself

Declarative knowledge :- Is passive knowledge in the form of statements of facts about the world, for example mark statement of a student is declarative knowledge and where that mark is to be used is unknown, or statements describing an object and its attributes including some behavior in relation to it.

Heuristic Knowledge

Heuristic knowledge are rules of the thumb or tricks. Heuristic knowledge is used to make judgement and also to simplify solution of problems

Heuristic knowledge is acquired through experience

An expert uses his knowledge that he/she has gathered due to his experience

Importance of knowledge

Intelligence requires knowledge i.e. to exhibit intelligence knowledge is required and knowledge plays a major role in building intelligent systems.

Knowledge Representation

Is the field of (AI) dedicated to representing information about the world in a form that a computer system can utilize to solve complex tasks such as:

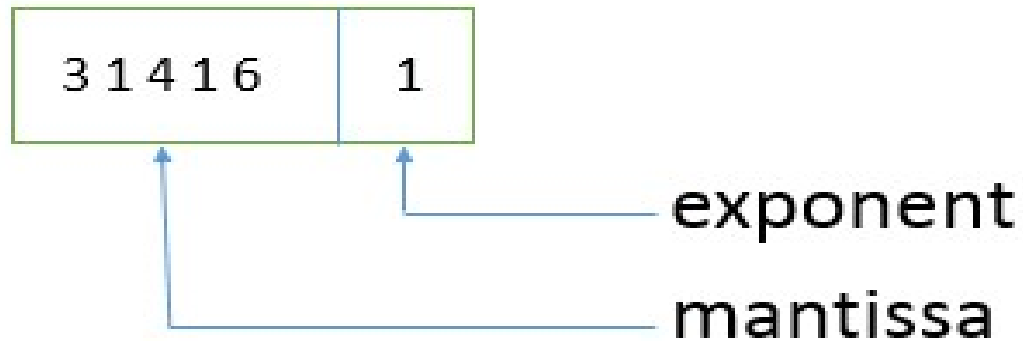
- Diagnosing a medical condition
- Having a dialogue in a natural language

Knowledge representation should provide a natural framework for expressing problem solving knowledge

Knowledge representation should make the knowledge available to the computer and assist the programmer in its organization

Knowledge representation

- Sometimes expressiveness is sacrificed to improve an algorithm efficiency, for example consider a computer representation of floating numbers:



Representation in the computer memory would be: 11100010

Floating representation

- Floating point representation sacrifices full expressive power to make representation efficient, in this case to make it possible
- This representation supports algorithms for multiple precision arithmetic giving effectively infinite precision by limiting round off error to any pre-specified tolerance.
- It also guarantees well behaved round off errors
- Like all representations it is only an abstraction or a symbol pattern that designates desired entity and not the entity itself

Types of knowledge representation

Different types of knowledge representations are:

- (i) Logic
- (ii) Semantic Network
- (iii) Frames
- (iv) Production Rules

Logic

A logic is a formal language, with precisely defined syntax and semantics, which supports sound inference.

Different logics exist, which allow one to represent different kinds of things, and which allow more or less efficient inference.

The logic may be of different types e.g.

- like propositional logic,
- predicate logic,
- temporal logic,
- description logic etc. But representing something in logic may not be very natural and inferences may not be efficient.

Logic

First – order Logic

Propositional Logic

Predicate Logic

Semantic network

Semantic network is a graphical knowledge representation technique

The semantic networks were developed to model human memory.

A semantic net consists of nodes connected by arcs.

The arcs are defined in a variety of ways, depending upon the kind of knowledge being represented.

The main idea behind semantic net is that the meaning of a concept comes, from the ways in which it is connected to other concepts. The semantic network consists of different nodes and arcs.

Semantic network

Knowledge is represented 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.

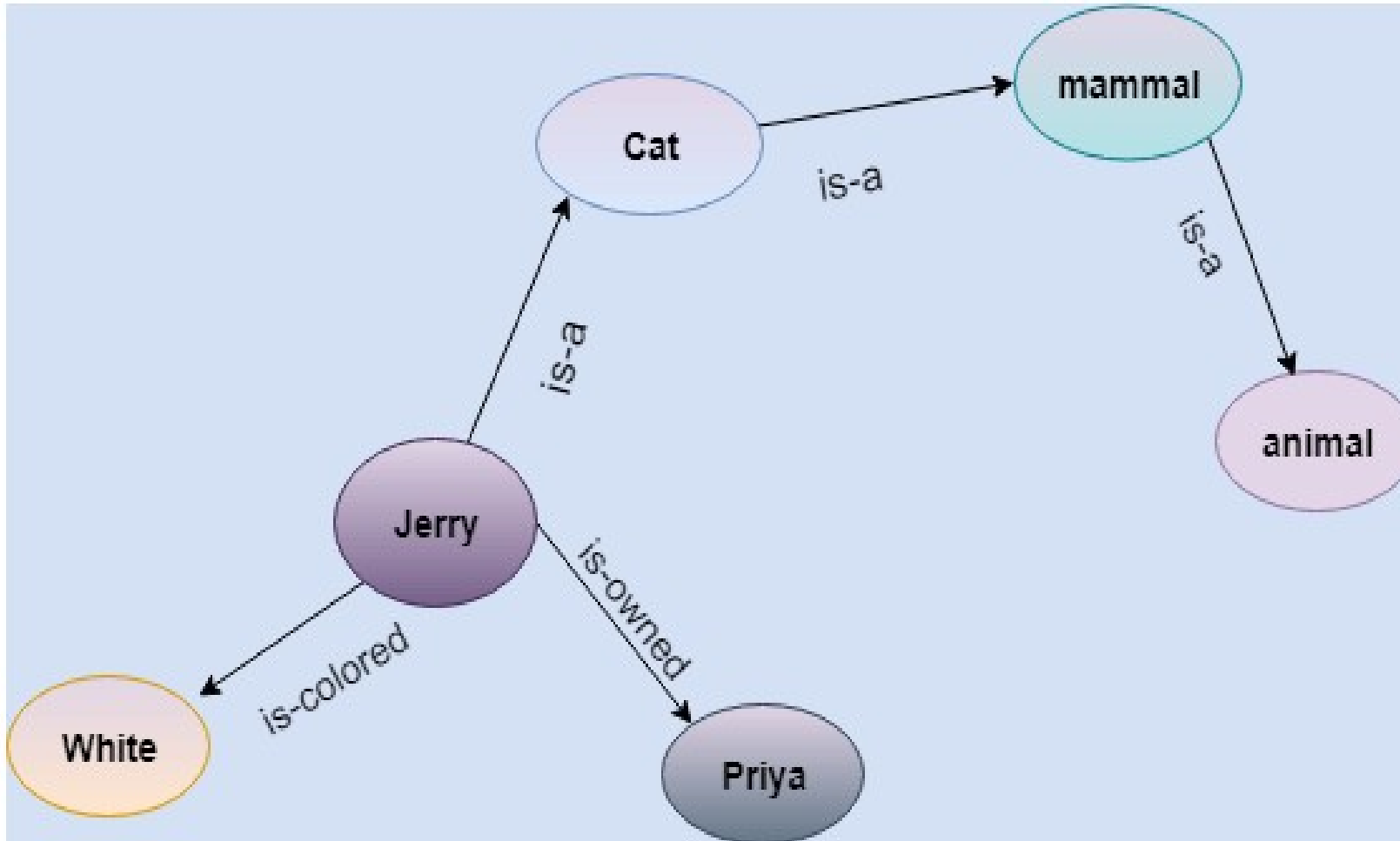
Example

Below are some statements which we need to represent in the form of nodes and arcs.

Statements:

- Jerry is a cat.
- Jerry is a mammal
- Jerry is owned by Priya.
- Jerry is brown colored.
- All Mammals are anima

Example of the network graph derived from the statements



Representing different types of knowledge in form of nodes and arcs

In the above diagram, we have represented the different types of knowledge in the form of nodes and arcs.

Each object is connected with another object by some relation.

Relations provide the basic structure for organizing knowledge

Advantages of semantic networks

- Semantic networks are a natural representation of knowledge.
- Semantic networks convey meaning in a transparent manner.
- These networks are simple and easily understandable.

Disadvantages

1. Semantic networks take more computational time at runtime as there is need to traverse the complete network tree to answer some questions. It might be possible in the worst case scenario that after traversing the entire tree, we find that the solution does not exist in this network.

Disadvantages

2. Semantic networks try to model human-like memory (Which has 10¹⁵ neurons and links) to store the information, but in practice, it is not possible to build such a vast semantic network.
3. These types of representations are inadequate as they do not have any equivalent quantifier, e.g., for all, for some, none, etc.
4. Semantic networks do not have any standard definition for the link names.
5. These networks are not intelligent and depend on the creator of the system.

Frame Representation

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.

have names and values which are called facets.

Facets

The various aspects of a slot is known as **Facets**.

Facets are features of frames which enable us to put constraints on the frames.

Example: IF-NEEDED facts are called when data of any particular slot is needed.

A frame may consist of any number of slots, and a slot may include any number of facets and facets may have any number of values.

A frame is also known as **slot-filter knowledge representation** in artificial intelligence.

Frames

Frames are derived from semantic networks and later evolved into our modern-day classes and objects.

A single frame is not much useful. Frames system consist of a collection of frames which are connected. In the frame, knowledge about an object or event can be stored together in the knowledge base.

The frame is a type of technology which is widely used in various applications including Natural language processing and machine visions.

Example of a book frame

Slots

Title

Genre

Author

Edition

Year

Page

Filters

Artificial Intelligence

Computer Science

Peter Norvig

Third Edition

1996

1152

Example of an entity frame e. g. Peter

Peter is an engineer as a profession, and his age is 25, he lives in city London, and the country is England. So following is the frame representation for this:

Slots	Filter
Name	Peter
Profession	Doctor
Age	25
Marital status	Single
Weight	78

Advantages of frame representation

- The frame knowledge representation makes the programming easier by grouping the related data.
- The frame representation is comparably flexible and used by many applications in AI.
- It is very easy to add slots for new attribute and relations.
- It is easy to include default data and to search for missing values.
- Frame representation is easy to understand and visualize.

Disadvantages of frame representation

- In frame system inference mechanism is not be easily processed.
- Inference mechanism cannot be smoothly proceeded by frame representation.
- Frame representation has a much generalized approach.

Production Rules

The term rule in AI is the most commonly used type of knowledge representation

Rule is an IF – THEN structure that relates to given information or facts in the IF part to some action in the THEN part

Any rule consists of two parts:

The IF part called the antecedent(premise or condition) and the THEN part called the consequent(conclusion or action)

Antecedent and Consequent

IF <antecedent>

THEN<consequent>

A rule can have multiple antecedents joined by keywords
AND(Conjunction), OR(disjunction) or a combination of both

IF <antecedent 1> IF <antecedent 1>

AND <antecedent 2> OR <antecedent 2>

AND<antecedent n> OR <antecedent n>

THEN<consequent> THEN <consequent>

Parts of an antecedent

Antecedent of a rule has two parts:

An object(linguistic object) and its value

The object and its value are linked by an operator

The operator identifies the object and assigns a value

Operators such as is, are, is not, are not are used to assign symbolic value to a linguistic object

example

IF 'age of customer' < 18

AND 'cash withdrawal' > 1000

THEN 'signature of the parent' required