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An Overview of Knowledge Representation Techniques

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ABSTRACT

Knowledge representation continues to be a much-researched topic in AI because of the realisation fairly early on that how information is arranged can often make or break an AI application. Thee main objective of this paper is to present the overall description of some commonly used knowledge representations techniques such as logic, semantic networks, production rules and frames.
Keywords: Knowledge Representation, Semantic Net, Frame, Production Rule.

I. INTRODUCTION

Knowledge is the body of facts and principles. Knowledge can be language, concepts, procedures, rules, ideas, abstractions, places, customs, and so on. Study of knowledge is called Epistemology.

A. Types of knowledge

The types of knowledge include procedural knowledge, declarative knowledge and heuristic knowledge.

Procedural knowledge: Procedural knowledge is compiled or processed form of information. Procedural knowledge is related to the performance of some task. For example, sequence of steps to solve a problem is procedural knowledge.

Declarative knowledge: 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.

Heuristic knowledge: Heuristics knowledge are rules of thumb or tricks. Heuristic knowledge is used to make judgments and also to simplify solution of problems. It is acquired through experience. An expert uses his knowledge that he has gathered due to his experience and learning.

To a large extent, the way in which you organise information available to and generated by your intelligent agent will be dictated by the type of problem you are addressing. Often, the best ways of representing knowledge for particular techniques are known. However, as with the problem of how to search, you will need a lot of flexibility in the way you represent information.

A knowledge representation (KR) is an idea to enable an individual to determine consequences by thinking rather than acting, i.e., by reasoning about the world rather than taking action in it. There are two basic components of knowledge representation i.e. reasoning and inference. It is a way of efficient computation in which thinking is accomplished. In cognitive science it is concerned with how people store and process information and in AI the objective is to store knowledge so that programs can process it. Constructing an intelligent system, require large amount of knowledge and a method for representing large amounts of knowledge that permits their effective use and interaction. In fact KR is the fundamental issue in AI that attempt to understand intelligence. There are three wide perspectives of knowledge representation [3] [18].

KR as applied epistemology: All intelligent system presupposes knowledge which is represented in a knowledge base that consists of knowledge structures (normally symbolic) and programs.

KR as a tell-ask module: KR system should provide at least two operations:

For a given knowledge base K, with the facts f. It must be resulting in a new knowledge base, K'.
The knowledge base K is being queried about a fact f. Outcome depends upon KR paradigm used, may be yes, no, unknown, yes with a confidence factor of A ...etc.

KR as the embodiment of AI systems: There are identical interconnected units that are collectively responsible for representing various concepts. A concept is represented in a Distributed sense and is indicated by an evolving pattern of activity over a collection of units.

II. LOGICAL REPRESENTATION

Certain logics are very popular for the representation of information, and range in terms of their expressiveness. More expressive logics allow us to translate more sentences from our natural language (e.g., English) into the language defined by the logic.

Some popular logics are:

A. Propositional Logic

This is a fairly restrictive logic, which allows us to write sentences about propositions - statements about the world - which can either be true or false. The symbols in this logic are (i) capital letters such as P, Q and R which represent propositions such as: "It is raining" and "I am wet", (ii) connectives which are: and (∧), or (∨), implies (→) and not (¬), (iii) brackets and (iv) T which stands for the proposition "true", and F which stands for the proposition "false". The syntax of this logic are the rules specifying where in a sentence the connectives can go, for example must go between two propositions, or between a bracketed conjunction of propositions, etc.

The semantics of this logic are rules about how to assign truth values to a sentence if we know whether the propositions mentioned in the sentence are true or not. For instance, one rule is that the sentence PQ is true only in the situation when both P and Q are true. The rules also dictate how to use brackets. As a very simple example, we can represent the knowledge in English that "I always get wet and annoyed when it rains" as:

It is raining → I am wet ∧ I am annoyed

Moreover, if we program our agent with the semantics of propositional logic, then if at some stage, we tell it that it is raining; it can infer that I will get wet and annoyed.

A. First Order Predicate Logic (FOPL)

This is a more expressive logic because it builds on propositional logic by allowing us to use constants, variables, predicates, functions and quantifiers in addition to the connectives we've already seen. For instance, the sentence: "Every Monday and Wednesday I go to John's house for dinner" can be written in first order predicate logic as:

∀ X ((day_of_week (X, monday) ∨ day_of_week (X, wednesday)) → (go_to (me, house_of (john)) ∧ eat_meal (me, dinner))).

Here, the symbols monday, wednesday, me, dinner and john are all constants: base-level objects in the world about which we want to talk. The symbols day_of_week, go_to and eat_meal are predicates which represent relationships between the arguments which appear inside the brackets. For example in eat_meal, the relationship specifies that a person (first argument) eats a particular meal (second argument). In this case, we have represented the fact that me eats dinner. The symbol X is a variable, which can take on a range of values. This enables us to be more expressive, and in particular, we can quantify X with the 'forall' symbol V , so that our sentence of predicate logic talks about all possible X's. Finally, the symbol house_of is a function, and - if we can - we are expected to replace house_of (john) with the output of the function (john's house) given the input to the function (john).

B. Higher Order Predicate Logic

In first order predicate logic, we are only allowed to quantify over objects. If we allow ourselves to quantify over predicate or function symbols, then we have moved up to the more expressive higher order predicate logic. This means that we can represent meta-level information about our knowledge, such as "For all the functions we've specified, they return the number 10 if the number 7 is input":

$$\forall f, (f(7) = 10).$$

C. Fuzzy Logic

In the logics described above, we have been concerned with truth: whether propositions and sentences are true. However, with some natural language statements, it's difficult to assign a "true" or "false" value. For example, is the sentence: "Prince Charles is tall" true or false? Some people may say true, and others false, so there's an underlying probability that we may also want to represent. This can be achieved with so-called "fuzzy" logics. The originator of fuzzy logics, Lotfi Zadeh, advocates not thinking about particular fuzzy logics as such, but rather thinking of the "fuzzification" of current theories, and this is beginning to play a part in AI. The combination of logics with theories of probability, and programming agents to reason in the light of uncertain knowledge are important areas of AI research. Various representation schemes such as Stochastic Logic Programs have an aspect of both logic and probability.

D .Other logics

Other logics you may consider include:

Multiple valued logics: where different truth value such as "unknown" are allowed. These have some of the advantages of fuzzy logics, without necessarily worrying about probability.

Modal logics: which cater for individual agents' beliefs about the world. For example, one agent could believe that a certain statement is true, but another may not. Modal logics help us deal with statements that may be believed to be true to some, but not all agents.

Temporal logics: which enable us to write sentences involving considerations of time, for example that a statement may become true sometime in the future.

III. SEMANTIC NET

A semantic network is widely used knowledge representation technique. As the name semantic network, it represents the connection between objects or class of objects.

A semantic net (or semantic network) is a knowledge representation technique used for propositional information. So it is also called a propositional net. Semantic nets convey meaning. They are two dimensional representations of knowledge. Mathematically a semantic net can be defined as a labelled directed graph.

Semantic nets consist of nodes, links (edges) and link labels. In the semantic network diagram, nodes appear as circles or ellipses or rectangles to represent objects such as physical objects, concepts or situations. Links appear as arrows to express the relationships between objects, and link labels specify particular relations. Relationships provide the basic structure for organizing knowledge. The objects and relations involved need not be so concrete. As nodes are associated with other nodes semantic nets are also referred to as associative nets.

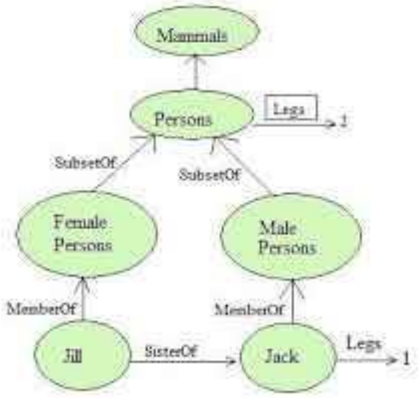

Figure 1. A Semantic Network

Following are six of the most common kinds of semantic networks.

- ✓ Definitional networks
- ✓ Assertional networks
- ✓ Implicational networks
- ✓ Executable networks
- ✓ Learning networks
- ✓ Hybrid netwok

IV. FRAME REPRESENTATION

When an agent encounters a new situation, it will need to retrieve information in order for it to act rationally in that situation. This information is likely to be multi-faceted and hierarchical, and one way of structuring the knowledge is in terms of frames. These are frameworks consisting of slots, with each slot containing information in various representations, including logical sentences and production rules. A slot can also contain another frame, which gives us a hierarchy.

Each framework represents a stereotypical object or situation and can be recalled whenever an agent encounters an object or situation which roughly fits the stereotype. After retrieving an appropriate frame, an agent will adapt it by changing some of the defaults, filling in blanks, etc. Some of the information is procedural, so that when a blank is filled in with certain values, a procedure must be carried out. Hence, not only will the frame provide a way of storing information about what is currently happening, it can also be used to dictate how to act rationally in that situation.

A typical frame for a book can be as follows:

Slots	Fillers
Publisher	Prentice hall
Title	Artificial intelligence
Author	Russell
Edition	5
Year	2015
Pages	418

Figure 2. A Typical Frame

To make the frame representation as flexible as possible, different types of information are allowed in the slots. These include:

Information for choosing the frame: This might be a name, or id number. It may also be information about situations in which this frame should be retrieved, or some descriptors for the stereotype the frame represents. For example, a frame for a table might give some physical specifications and if a new object fits those specifications to a degree, then the frame should be retrieved.

Information about relationships between this frame and others: For example, whether this frame is a generalisation or specialisation of another frame, or whether two frames should never be considered at the same time.

Procedures which should be carried out after various slots have been filled in: These procedures could include: filling in particular values in other slots, retrieving other frames, or any rational action an agent should do in a situation where a particular value for a slot has been identified.

Default information: In situations where certain information required for the frame is missing, defaults can be specified. For instance, a table may be assumed to be wooden until this information can be ascertained. Default information is used in choosing actions until more specific information is found.

Blank slots: These are flagged to be left blank unless required for a particular task. For example, in a frame for lectures, the room of the lecture may be irrelevant for taking notes, but become important when planning how to get to lunch afterwards.

V. PRODUCTION RULE REPRESENTATIONS

Another way to represent knowledge is as a set of production rules. These are condition-action pairs which define a condition which, if satisfied in a certain situation, causes the production rule to "fire", i.e., the action to be carried out. In terms of the previous lecture on search, production rules use the current state in the search to check a condition, and if the condition is satisfied, the action part of the production rule chooses which operator to use, and carries out the operation.

VI. CONCLUSION

In AI there are various knowledge representation schemes which have their own semantics, structure and different level of power. This paper described briefly few common knowledge representation schemes Each knowledge representation scheme has also its own benifits and limitations. More improvements can be done used to make the various schemes more efficient and powerful.

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