UNIT 6 KNOWLEDGE BASED RETRIEVAL SYSTEMS

Structure

6.0 OBJECTIVES

After reading this Unit, you will be able to :

- understand the concept and need for Knowledge Based Systems; and
- know the structure and design of Expert Systems.

6.1 INTRODUCTION

Knowledge based systems are sometimes termed intelligent decision support systems. A Decision Support System (DSS) is a tool that assists the decision-maker in formulating and solving complex problems. A DSS is primarily intended to facilitate data analysis by a human and leaves the role of interpretation and decision making to the user. Knowledge based systems and expert systems are explicitly intended to have proactive reasoning capabilities and to be capable under proper conditions of assuming a portion of the interpretation and decision-making role. In the field of AI, an interdisciplinary field of computer science and cognitive psychology, early research efforts focused on generality, which was seen as the keystone of human intelligence. Intelligence appeared to reside in a small collection of domain independent problem solving methods. However, subsequent research in the field of Artificial Intelligence (AI) found that although the early methods were useful, they were inadequate to deal with complex real world problems. Performance in such problems seemed to require large stores of domain specific knowledge and process that knowledge in a more human like fashion than conventional methods do. As a result, systems have been developed that can model human expertise of a well defined field and offer

intelligent support to a practitioner. These are commonly referred to as knowledge based expert systems or knowledge systems.

6.2 KNOWLEDGE BASED SYSTEMS

The Knowledge Based Systems (or more commonly called expert systems) use domain specific knowledge in addition to general knowledge. They employ heuristic method as well as algorithmic methods. They perform well in the domain or problem area, i.e., generate an accurate and useful solution in a reasonable amount of time. These systems are capable of explaining knowledge and its rationale for proposed solutions. The other important characterization of knowledge based systems are that they are flexible, which means that they can be modified and expanded by adding to or deleting from the knowledge base without the need for rewriting the programme itself.

Knowledge based systems are designed and developed using a process of knowledge engineering undertaken by a specialised systems analyst known as a knowledge engineer. Knowledge engineering is a system development methodology similar to those used to construct conventional applications.

Knowledge engineering encompasses all of the individual tasks required for the construction of a knowledge based system which includes the following :

1) **Problem identification and characterization -** Description of the specific problem to be addressed by the system, including the following :

   a) The type of the problem - diagnosis, prediction, simulation, planning etc.

   b) Problem domain- disease management, nurse scheduling, equipment trouble shooting.

2) **Requirement analysis -** Identification of system users and determination of the form and substance of information, the system must present to the users in order to provide a viable solution.

3) **Knowledge Acquisition -** Identification, collection and modeling of information required for the knowledge based system. The information can come from the following :

   a) Written documentation - technical reports, company literature, books, notes.

   b) Reporting of data either in written or electronic form.

   c) Human expert whose knowledge is generally elicited through interviewing and observational technique. Knowledge engineering tends to focus on both the experts corpus of domain knowledge and the experts style of reasoning and problem solving.

4) **Programme Development -** Incorporation of acquired knowledge within an expert system/ knowledge based systems using a development tool or programming language.

5) **Installation and Testing -** Comparison of ES/KBS output with performance criteria (i.e. system verification and validation).

Some Existing Expert Systems

	Area
AQ11	Diagnosis of plant disease
Casnet	Medical consulting
Dipmeter Advisor	Oil Exploration
Mycin	Medical consulting
Prospector	Mineral Exploration

Expert Systems in Library and Information Domain

In recent years some expert system have been developed in library and information area. Some of these are :

i) **Ready Reference Advisor -** It is an expert system designed to assist novice users in finding answers to common library reference questions. The system was developed for the National Agricultural Library (NAL), USA.

ii) **RAS (Reference Advisory System)** is an expert system developed at San Diego State University to assist in providing reference sources.

iii) Pertaining to collection development and acquisition an expert system "**Librarian Assistant**" has been developed. The domain of this system is the collection of the Applied Physics Laboratory at John Hopkins University (USA).

iv) **'N-Cube' expert system** reported by Cosgrove to assist in the classification of library materials using UDC. This system combines shallow knowledge usually represented as production rules and deep knowledge usually represented in a frame structure. N-cube architecture consists of a parent class, sub classes, a set of rules, class inheritance and a set of properties.

v) In the area of library education for training of professional librarians the **'YES SIR' expert system** has been developed to assist in retrieval tasks.

Paulter and others in their report, which appeared in ARIST, Vol. 28, 1994, have claimed 139 expert system projects in LIS domain.

6.3 EXPERT SYSTEMS: CONCEPT AND DEFINITION

The term "expert system" refers to a system that uses contemporary computer technology to store and interpret the knowledge and experience of a human expert, sometimes several experts in a specific area of interest. By accessing this computer-based knowledge, an individual is able to get the benefit of expert advice' about that particular area.

Feigenbaum has defined an expert system as an "Intelligent computer programme that uses knowledge and inference procedure to solve problems that are difficult enough to require significant human expertise for their solutions". Knowledge necessary to perform at such a level plus the inference procedure used can be thought of as a model of the expertise of the best practitioners in the field.

The knowledge of an expert system consists of facts and heuristics. The facts constitute a body of information that is widely shared, publicly available and generally agreed upon by experts in the field. The heuristics are mostly private, little discussed rules of good judgment that characterise expert level decision making in the field. The performance level of an expert system is primarily a function of the data and quality of the knowledge base it possesses.

Those who build knowledge based expert systems are knowledge engineers and their technology is known as knowledge engineering.

The knowledge engineer focus is on replicating the behaviour of an expert of a specific field engaged in solving a narrowly defined problem to develop computer systems that will provide results that are normally associated with human intelligence.

The types of generic problems they are intended to solve also distinguish ES/KBS. The problems that are most appropriate to Expert System/Knowledge Based Systems are :

i) Interpretation of data for situational assessment

ii) Construction of a solution, given an imposed set of constraints.

An early examples of an expert system is DENDRAL System developed at Stanford University. The system was developed for interpreting spectroscopic data to determine the molecular structure of unknown compounds. MIT developed MACSYMA system for symbolic manipulation of algebraic expressions.

6.4 STRUCTURE OF EXPERT SYSTEMS

Expert systems were developed in the 1970's. With advancement in A.I. researchers, the HIPS model of human cognitive system was used to develop the production rule in the form of a programming language called "production system". The production system is based on the basic idea that the database consists of rules called *productions* in the form of condition-action pairs : *IF* this condition arises, *THEN* take this action". The system consist of two parts : (a) Production rules of *IF-THEN* statements, and (b) a working memory. In simple language, a production rule is an instruction for recognise act processors. Production rules (or simply productions) are applied to working memory.

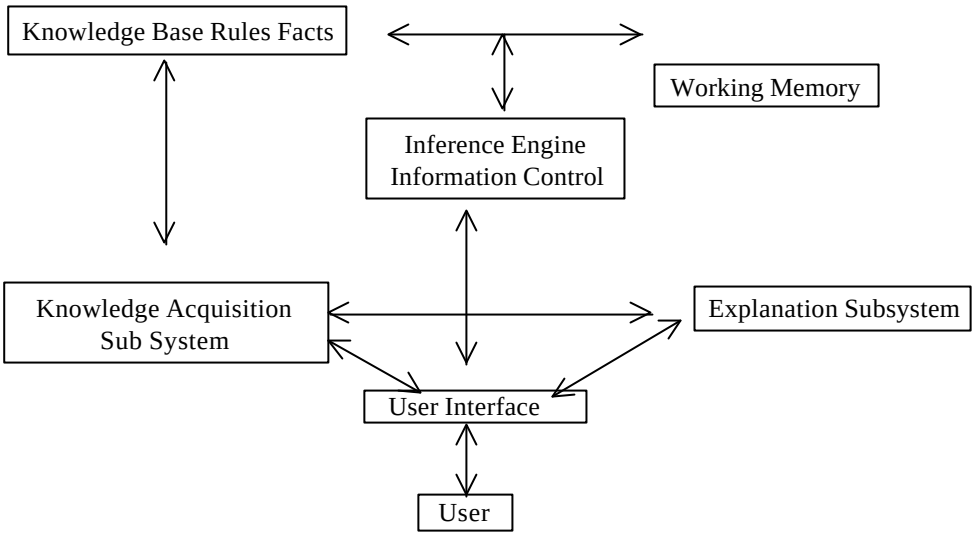
An expert system is built using the production rule derived from the Human Information Processing System (HIPS) model. It consists of two major parts : (a) The Knowledge Base including the working memory and, (b) The Inference Engine.

Experts solve problems by employing a large number of task-specific facts and heuristics. An expert is an "individual" who is widely recognised as being able to solve a particular type of problem that most other people cannot solve in an effective and efficient manner.

Experts perform well because they have a large amount of compiled task- specific knowledge stored in LTM. According to one estimate, a nobel laureate in chemistry has 50000 to 100,000 chunks of heuristic information about his reality. The human experts arranges the knowledge in his LTM so that he can respond to a problem situation by using heuristics and task specific theories.

The knowledge engineer builds a knowledge base by capturing the knowledge of a human expert. This is done through the knowledge engineer talking to experts and asking him to describe various aspects in his/her domain. The knowledge engineer collects elements or objects, identifies the characteristics of each of the object and analyses and establishes relationships linking objects (concrete or conceptual) that constitute knowledge stored in the expert's LTM.

The architecture of the knowledge based expert system is given below :



The major components of the expert system are:

i) Knowledge Base

ii) Inference Engine

In a rule based system, the knowledge base consists of : (i) a working memory, (ii) a rule base: A set of IF-THEN rules.

Inference Engine is the mechanism by which facts are matched to rules and rules are united together to form a set of conclusions and possible actions. Consequents are proven from antecedents through a principle of logic called modus ponens.

6.5 METHODS OF KNOWLEDGE REPRESENTATION

The most important stage in the construction of an expert system is representation of knowledge itself. The knowledge representation research in AI has been concerned with the syntax and semantics of the representation of knowledge.

There are several ways to represent factual information in a rule-based system, a common method is the use of predicate calculus. A rule is structured as a link between the conjunction of one or more antecedents and a set of consequents.

IF <antecedent 1> *THEN* <consequent 1>

IF <antecedent 2 > *AND* <antecedent 3> *THEN* <consequent 2 >

The antecedent of a rule is an assertion describing the observed or inferred state of the world while the consequent can be either of the following:

— A conclusion or inference drawn from an assertion

— An action to be taken

A variety of methods have been developed by AI researchers to represent knowledge in the computer with a shift towards semantics. These include :

— Semantic networks

— Object – Attribute – Value (O-A-V) triplet

— Rules

— Frames

— Logical Expression

Semantic Networks

The scheme of semantic networks was first proposed by Quillian and evolved rapidly to become a major concept in knowledge representation. Semantic networks are a collection of objects called nodes. Nodes are connected together by arcs or links. Nodes are used to represent objects and descriptors. The objects may be physical entities or conceptual entities. The descriptors provide additional information about objects. The links relate objects and descriptors. A link may represent any relationship. The semantic network scheme possess two distinct advantages, namely flexibility and inheritance.

Object Attribute Value

Another method of representing knowledge is O-A-V triplets. In this scheme, Objects (O) may be a physical or a conceptual entity, attribute (A) may be general characteristics or properties associated with objects; Value (V) in the scheme represents the specific nature of an attribute in a particular situation. The O-A-V triplet scheme is a specialized form of semantic network approach.

Knowledge in the form of facts and rules is stored in the knowledge base of an expert system and represents static knowledge. When a user interfaces with the knowledge base and determines the values of various attributes relative to the particular situation, he generates dynamic knowledge. The system stores this dynamic knowledge in its working memory for reasoning. The process of determining specific values for the attributes stored in a static knowledge base is aften called instantiation.

Rules

The rules based scheme of knowledge representation is one of the most commonly and easily understood approaches. The basic premise of the scheme is that for each type of problem a set of rules exist that solve it. A rule condition is specific enough to identify the problem and generate a search space. The most common approach of the rules scheme is production. The rules (called production) are in the form of condition action pairs. IF this condition arises THEN take this action. Rules are thus represented in the from of IF, THEN, AND, and OR logical operators, e.g.

IF Holiday in University THEN Employee need not take leave for going out of station

IF <A Student of Library Sc> AND <Studying in BHU> THEN <Eligible for Das scholarship>

Typical Rules are :

Rule 1 : The organism grows in chain and
IF The organism grows in pairs and
The organism grows in clumps
THEN The organism is streptococcus

Rule 2 : IF The organism is streptococcus
THEN The infection is bacterial

Rule 3 : IF The infection is bacterial and
THE Patient has no allergies
THEN Treat with penicillin

Frames

In 1975 Minsky introduced the concept of frame for knowledge representation. A frame partitions a semantic network into easily identifiable concept. It represents knowledge in the form of a description of an object that contains slots for all of the information associated with the object, slots like attributes, may store values. A frame is a data structure for representing a stereotyped situation. Frames permit a richer representation of knowledge. However, they are far more complex and more difficult to develop. An important feature of the frame scheme is its ability to determine whether it is applicable in a given situation. Frames provide structured representation of objects or classes of objects. So frames can incorporate sets of attributes description called slots. A distinguishing characteristics of a frame based language is that a frame representing a class can contain a prototype description of a member of the class as well as a description of the class. Slots in most frame systems can have multiple values and sets of properties.

Logical Expression

Logic provides another way of representing factual and representational knowledge. The several logical forms of knowledge representation are : propositional logic and predicate calculus. The propositional logic system contain statements that are either true or false. Prepositions that are linked together with connectives such as AND, OR, NOT, IMPLIES and EQUIVALENT. Propositional logic is concerned with truthfulness of compared statements depending on connectives.

The kind of knowledge that can go into a knowledge base: Behaviour description, vocabulary description, objects and relationship, decision rules, typical situation, hypothesis, uncertain facts, processes, constraints, heuristics and disjunctive facts.

Employee :

Attribute	Value
Name	A.M. Singh
Position	Asstt. Librarian
Department	Central Library
University	Kashividyapeeth
Telephone	318513

An example of frame, showing slots and values.

6.6 INFERENCE ENGINE

Every expert system requires a mechanism to make inference based on the stored knowledge. The knowledge base is simply a collection of Rules and Facts concerning a defined subject domain. The inference and control mechanism directs the system in its use of facts and rules contained in the knowledge base. It is through the inference engine that the fact are matched to rules and rules are linked together to form a series of conclusions and possible actions.The inference engine contains an inference and control mechanism that directs the system in it use of facts and rules contained in the knowledge base.

The inference and control mechanisms are based on the following :

Inference

— Modus Ponens

— Reasoning about uncertainty

— Resolution

Control

— Forward and backward Chaining

— Depth first versus breadth-first search

— Monotonic versus non-monotonic reasoning

The Modus Ponens is the logical rule for deriving new facts from rules and known facts. The consequents are proven from antecedents through a principle of logic, which takes an assertion (A is true) and a rule (IF < A is true> THEN <B is true>), and derives a new assertion from the relationship (B is true).

(X is A) and { (X is A) $\rightarrow$ (Y is B) }

However, the inference can be made only if the conditional assertion { X is A} is identical to the premise of the conditional assertion (rule). Therefore to cover all the possible situations, we need as many rules as the number of different values that X can take.

The presence of uncertain information in an expert system can be associated with at least four causes. The first type is related to the reliability of information : uncertainty can be present in factual knowledge (i.e., set of assertions or facts). Uncertainty can also occur in the knowledge base (i.e., the rule set) as a result of weak implications. There can be uncertainty in data. The third type of uncertainty occurs when inference is based on incomplete information. In this case we need to partially match facts and premise, i.e., we wish to allow for the value “unknown” during the evaluation of the degree of certainty of the premise. The fourth type of uncertainty arises from the aggregation of rules from different knowledge sources or different experts. There are four possible errors that can occur in knowledge represented as production rule: conflicting, redundant, subsuming and missing rules. Representation of uncertainty in the expert system literature may be classified into three categories : Numerical characterisation, reasoned assumption, and qualitative endorsement. The unknown information is handled by logical rules : AND or IF - THEN.

Resolution is a set of logical statements to discover whether a new fact is to be valued

Control

The control mechanism of the inference engine is concerned with the two problems faced while interfacing a knowledge system :

a) The way to decide where the reasoning process is to begin

b) Resolving conflicts that occur when alternative lines of reasoning emerge.

The control mechanism can take one of the following three approaches:

i) Forward chaining

ii) Backward chaining

iii) A combination of forward and backward chaining

In forward chaining, the reasoning is data driven. The system begins with information about the state of the world then reasons forward through the set of rules from antecedent to consequent, until some conclusion is reached. The inference engine begins by collecting rules having an antecedent, i.e., consistent with the state of the world. In situations in which more than one rule has a matching antecedent, the inference engine uses a conflict resolution strategy. In forward chaining the existing facts in the working memory would be matched with the antecedent of the first rule, which then would store the consequent in working memory. In turn the antecedent of the second rule would match the new fact, which would cause the rule to find and store its consequent in working memory. This process would continue until all matching rules have been exhausted.

In forward chaining, all the rules are placed in one ranked list and all the true assertions are placed in another ranked list. The inference engine traverses the rules list

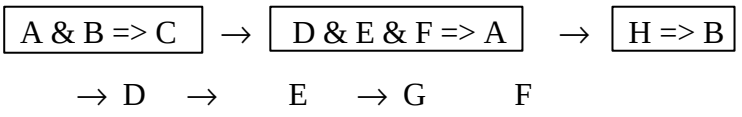


Fig. 2

But in backward chaining the reasoning is hypothesis or goal driven, and the direction of inference is reversed. The system that reasons backwards starts with a goal and works backwards through the sub-goals in an effort to choose an answer. Each premise of the rule retrieved becomes a new goal, in turn, and rules relevant to those goals are retrieved. Reasoning backward from the initial goal towards more primitive data continues until the system encounters topics for which there are no rules.

Depth first search strategy permits inferring sub-goals as well as searching for details in depth from action to means and to distance. While some systems use monotonic reasoning, some use non-monotonic reasoning. In monotonic reasoning all the values concluded for an attribute remain true for the duration of the consultation session. Facts that become true remain true, and the amount of true information in the system grows steadily or monotonically. But in non-monotonic reasoning, facts that are true may be retracted.

6.7 AI LANGUAGES

The expert system is an offshoot of the field of artificial intelligence. The term artificial intelligence was first used by McCarthy in 1956. Artificial Intelligence is that field of computer science that studies how machines might behave like people. AI programmes commonly use high level AI language such as List Processing (LISP) and Programming Language for logic (PROLOG). The LISP consists of operators that facilitate the creation of programmes that manipulate lists. The list can be used to represent relations between the things represented by the symbols. Manipulation of these list structures can deduce implicit relations. Programmes can use lists to build structures of unpredictable size and shapes.

In the LISP, the computing is with symbolic expressions rather than numbers. It represents data as linked list structure in the machine and as multilevel lists on paper. Since there is no essential difference between data and programms in LISP, one LISP programme can be used in another LISP programme as data.

The idea that logic could serve as a programming language, was put to practiced use around 1972 in the form of Prolog. Logic has traditionally provided a firm conceptual framework for representing knowledge. The introduction of Prolog has made it possible to represent knowledge in terms of logic and also to expect appropriate inferences to be drawn automatically.

One can express knowledge in Prolog in terms of either fact or rules. The basic units for building fact or rules are predication, for example “Sweeti likes Rose” is represented as Likes (Sweeti, Rose)

Predication, in short, is represented by a predicate name (e.g, likes) followed by a list of arguments. Each Argument can be (i) name of an individual, also called constant (e.g, “Sweeti”, “Rose”). The logic programming methodology can be used for describing and retrieving general knowledge about the world. Prolog has two programming style : a declarative style and a procedural style. In the declarative programming style, one focuses on telling the system what it should know and rely on the system to handle procedure. In procedural programming, one considers the specific problem-solving behaviour the computer will exhibit. Most expert systems use procedural style.

6.8 TOOLS FOR BUILDING EXPERT SYSTEMS

Expert system development tools generally provide support for representing symbolic knowledge. Many AI applications share common methods for representing knowledge, controlling inference and maintaining large systems. The expert system building tools provide standard ways for representing knowledge about a similar problems domain and task, and a standard inference procedure. There is a need for objective information on commercial software tools for building expert systems. The tools provide specific techniques for holding knowledge representation, inference and control, which helps knowledge engineers to model the salient characteristics of a particular class of problems. Various techniques are used to represent this knowledge including predicate calculus, logic programming, rules, semantic networks and frames or schemata. The LISP programming can be painstaking and resulting in code can be opaque. Many researchers have chosen to use or develop knowledge

representation language that allows them to encode knowledge at a higher level, perhaps closer to how a person may conceptualise it. The framework for tools initially emerged from an expert system designed at Stanford for medical diagnosis, EMYCIN is a tool for building MYCIN like consultant systems. There are other important tools like : S.1, KEE, Knowledge craft, ART, Rulecons.

i) **S.1. (Teknowledge)**

S.1. is a tool for developing a rule-based consultation system designed to solve standard selection problems in which there is an enhanced set of solutions. The design of S.1 is based on the EMYCIN system.

ii) **KEE (Knowledge Engineering Environmental Intellicrop)**

KEE is a hybrid tool integrating several AI methodologies into a single system. It provides support for frame-based knowledge representation with taxonomic inheritance, rule-based reasoning, logic representation, data-driven reasoning, object-oriented programming, interactive graphics.

iii) **Knowledge Craft (Carnegie Group Inc.)**

Knowledge craft is a hybrid tool with features similar to KEE. It combines frame-based, rule-based, logic-based, object-oriented, and LISP programming in one system.

iv) **ART (Automatic Reasoning Tool, Inference Corporation)**

Art is an integrated tool based on a powerful rule based language that supports hypothetical reasoning and other features. ART integrates rules, frames, logic and LISP functional programming into one system. ART is written in common LISP and is currently supported on the symbolics. ART is a powerful programming environment and is appropriate for solving a large class of problems.

v) **Rulecons** is an expert system to aid the formulation of knowledge bases. Rulecons assists the expert system developer or knowledge engineer during the interview of the expert (s). It is a system for creating domain-independent, rule-based knowledge bases.

Self Check Exercise

1) Explain the concept and structure of Expert System.

2) Describe the different methods of knowledge representation.

3) What is the function of Inference Engine?

Note : i) Write your answers in the space given below.

ii) Check your answer with the answers given at the end of this Unit.

.....

.....

.....

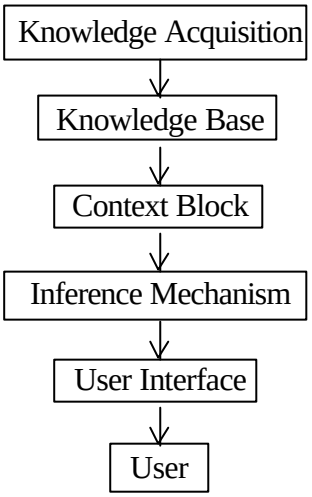
.....

.....

6.9 SUMMARY

Artificial Intelligence (AI) is a subfield of computer science concerned with making machines perform intelligence tasks and suitable intelligence behaviour of human beings. Most of the research in AI was directed towards non-numeric computation and symbolic reasoning, because it was realized that operation rather than numerical computation operation are involved in many cognitive activities. Researchers of AI developed representation schema to encode such facts. Expert systems have borrowed ideas such as knowledge representation techniques and heuristic programming and have tailored these ideas for use in relatively specialized fields. Expert systems have been built up in diverse branches of science, information service and management. These are essentially knowledge based systems. The entire process of developing expert systems is summarized below :

Domain Expert / Knowledge Engineer



Process of Knowledge Based Expert System Development

The knowledge that we consider for practical databases requires careful mapping from the conceptual model to physical storage. The logic programming languages have enabled us to provide intelligent databases. Expert systems have the capability of expert level performance in specialized fields. The expert system not only use heuristic rules, but has also a model of the domain so that deeper reasoning is possible if the rules are inadequate. A number of tools have been developed to assist in building knowledge based systems.

6.10 ANSWERS TO SELF CHECK EXERCISES

1) An expert systems is a knowledge-based information system based an the artificial intelligence technique (AI) which provides solutions to problems in a field in the same manner as human experts do. It is an attempt to simulate expert human behaviour by capturing his knowledge and mode of reasoning, thus giving way to more generic terms knowledge-based system. The expert system has been defined as an intelligent computer programme that users knowledge and inference procedure to solve problem that are difficult enough to require sufficient human expertise for their solutions.

The main structural components of the expert systems are :

1) Knowledge Base Rules Facts

2) Inference Engine

3) User Interface

The knowledge base is built by capturing the knowledge and heuristics of a human expert. The knowledge is represented in the form of facts and rules. The inference engine stands between the user and the knowledge base. Its main task is to draw inference and also control the order in which the inferences are to be made. The user interface assists in the interaction of the user with the system.

2) The different methods of knowledge representation in the knowledge base are:

   i) Semantic networks

   ii) Object – Attribute – Value (O-A-V) triplets

   iii) Rules

   iv) Frames

   v) Logical expression

Knowledge is represented as a set of rules and factual knowledge. A rule is structured as a link between the conjunction of one or more antecedents and a set of consequents.

IF <antecedent 1 > *THEN* <Consequent 1>

IF <antecedent 2 > *AND* <antecedent 3 > *THEN* <Consequent 2>

The antecedent of a rule is an assertion describing the observed or inferred state of the model, while consequent can be a conclusion inference drawn from an assertion or an action to be taken.

3) The inference engine stands between the user and the knowledge base and performs two major tasks :

   i) it examines existing facts and rules and adds new facts when possible.

   ii) it decides the order in which inferences are made.

Thus it formulates strategies used to draw inferences and control the reasoning process. Inference and control strategies guide a knowledge system as it uses the facts and rules stored in its knowledge base and the information it acquires from the user.

6.11 KEYWORDS

Domain Expert : A person whose knowledge and experiences have been used to produce information about a specific area of interest and store it in an expert system.

Inference Engine : Inference Engine is another key component of all expert systems. It is responsible for interpreting

the contents of the knowledge base in the context of a user-specified input or hypotheses in order to reach a goal or a conclusion. It can be divided into three parts-

i) Context Block

ii) Inference (Reasoning) mechanism

iii) Explanation facility

Knowledge Engineer : A person who works with a domain expert to encode the knowledge. In some cases the domain expert also acts as the knowledge engineer.

Knowledge Base : knowledge base is an essential module of all expert systems. It contains the formal representation of the information provided by the domain expert as encoded by the knowledge engineer.

Knowledge Acquisition Facility : New knowledge is generated with the assistance of this facility.

User Interface : User interface is a module of the expert system which permits the user to benefit from the system.

6.12 REFERENCES AND FURTHER READING

Awad, E.M., (1996) Building Expert Systems: Principles, Procedures and Application. Saist Paul, MM : West.

Buchanan, B. G, and Smith, R. G. (1989). Fundamentals of Expert Systems. *In* Handbook of Artificial Intelligence. A. Barr, P.R. Cohen and E.A. Feigenbaum, ed. Reading, M. A. : Addison – Wesley. pp. 149-192.

Clocksin, W.F. and Mallish, C.S. (1981). Programming in prolog. Berlin: Springer-Verlag.

Cosgrove, S.J. (1981) Item Classification using the 'N-cube's' Hierarchical Knowledge Representation Scheme. *In* Libraries and Expert System. Ed. by Mcdonald, Craig and Weckert John. London: Tayler Arahem, pp. 88-98.

Davis, R. and Lenal, D.C. (1982). Knowledge Based Systems in Artificial Intelligence. NY: McGraw Hill.

Davis, Randall (1986). Knowledge Based System . *Science* 231; Feb. 1986, 957.

Feigenbaum, E.A. (1985) Lecture notes, Nov. 10, 1983. *In* Expert Systems : Artificial Intelligence in business. Ed. by Paul Hermen and David King. N.Y. : Wiley p.5.

Gupta, Amar and Prasad, Banddredi E. (1988). Principles of Expert Systems. NY. : IEEE Press, 1988.

Haye- Roth, F et al ed, (1983) Building Expert Systems. NY: Addison Wesley.

Kowalski, R,. (1979) Logic for Problem Solving. Amsterdam: North-Holland.

Mewell, A. (1973) Production Systems: Models of Control Structures. *In* Visual Information Processing.

Pantter, A etc (1994) L I S Professionals as Knowledge Engineers *In* ARIST. N.J.: Learned Inf Inc. vol. 28.

Quine, W.V. (1970). Philosophy of Logic. N.J. : Prentice Hall, 1970.

Reiter, R. (1980). Logic for Default Reasoning. *Artificial intelligence*. 13; 1980, pp. 81.132.

Waterman, D.A. (1996). A Guide to Expert Systems. Reading M. A.: Addison – Wesley. pp. 1986.

William, James G. and Sochats, Ken (1996). Application of Expert Agents / Assistants in Library and Information Systems *DESIDOC Bulletin of Inf. Technology*. 16(4); 1996; pp19-32.