ASSIGNMENT 4

1) Briefly describe various aspects such as explanation sub-system, knowledge acquisition, inference mechanism etc. of MYCIN.

Answer) MYCIN, an early expert system, or artificial intelligence (AI) program, for treating blood infections. In 1972 work began on MYCIN at Stanford University in California. MYCIN would attempt to diagnose patients based on reported symptoms and medical test results. The program could request further information concerning the patient, as well as suggest additional laboratory tests, to arrive at a probable diagnosis, after which it would recommend a course of treatment.
An expert system shell is a software development environment containing the basic components for building expert systems. For every domain specific system, a knowledge engineer prepares a knowledge base with the help of domain experts in a particular area. A shell is associated with a prescribed method for building applications by configuring and instantiating these components.

MYCIN's Knowledge Base: IT organized a set of production rules. It was a set of IF-THEN-ELSE statements with the use of a distinguishing feature called Certainty factor.
MYCIN's Reasoning and Problem Solving Strategy: It used backward chaining to find out whether a possible bacteria was to blame or not. This was again augmented by certainty factors.
MYCIN's Explanation: It also worked on a fact resolution process marking them 'askable' which would be asked to the user.

2. Briefly describe various aspects such as explanation sub-system, knowledge acquisition,inference mechanism etc. of DENDRAL.

Answer) DENDRAL, an early expert system, developed beginning in 1965 by the artificial intelligence (AI) researcher Edward Feigenbaum and the geneticist Joshua Lederberg, both of Stanford University in California. Heuristic DENDRAL (later shortened to DENDRAL) was a chemical-analysis expert system. The substance to be analyzed might, for example, be a complicated compound of carbon, hydrogen, and nitrogen. Starting from spectrographic data obtained from the substance, DENDRAL would hypothesize the substance's molecular structure. DENDRAL's performance rivaled that of chemists expert at this task, and the program was used in industry and in academia.
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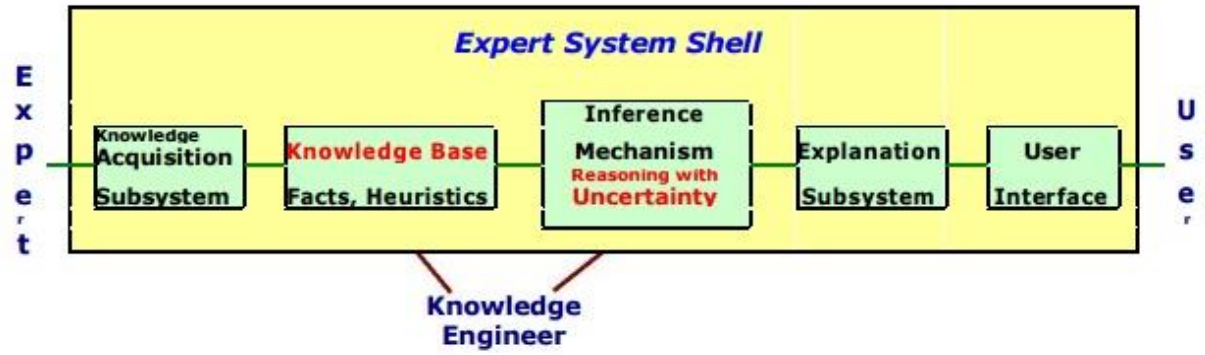
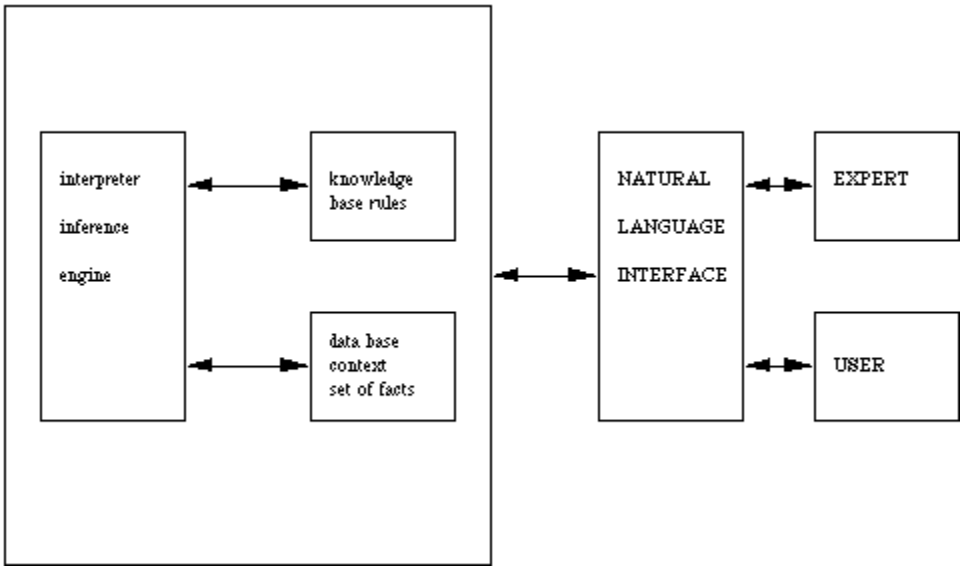


DENDRAL's Knowledge Engineering: The primary aim of the knowledge engineering was to devise a bridge between the available knowledge base and problem solving techniques. It was designed to be used for both to search for possible chemical structures that match the input data, and to learn new general rules that help prune searches.
DENDRAL's Heuristics: It's a program that uses mass spectra or other experimental data together with a knowledge base of chemistry, to produce a set of chemical structure that might be responsible for producing the data. A mass spectrum of a compound is produced by a mass spectrometer and is used to determine its molecular weight, the sum of masses of its atomic constitutes.

3. Structure of an Expert System? Rule based Architecture of Expert System? Applications of Expert Systems?

Answer) The internal structure of an expert system can be considered to consist of three parts:the knowledge base ; the database; the rule interpreter. This is analogous to the production system where we have the set of productions; the set of facts held as working memory and a rule interpreter.



The knowledge base holds the set of rules of inference that are used in reasoning. Most of these systems use IF-THEN rules to represent knowledge. Typically systems can have from a few hundred to a few thousand rules.

The database gives the context of the problem domain and is generally considered to be a set of useful facts. These are the facts that satisfy the condition part of the condition action rules as the IF THEN rules can be thought of.

The rule interpreter is often known as an inference engine and controls the knowledge base using the set of facts to produce even more facts. Communication with the system is ideally provided by a natural language interface. This enables a user to interact independently of the expert with the intelligent system.

The most common form of architecture used in expert and other types of knowledge based systems is the production system or it is called rule based systems. This type of system uses knowledge encoded in the form of production rules i.e. if-then rules. The rule has a conditional part on the left hand side and a conclusion or action part on the right hand side. For example

If: condition1 and condition2 and condition3
Then: Take action4

Each rule represents a small chunk of knowledge to the given domain of expertise. When the known facts support the conditions in the rule's left side, the conclusion or action part of the rule is then accepted as known.

Applications of Expert System:

Application	Description
Design Domain	Camera lens design, automobile design.
Medical Domain	Diagnosis Systems to deduce cause of disease from observed data, conduction medical operations on humans.
Monitoring Systems	Comparing data continuously with observed system or with prescribed behavior such as leakage monitoring in long petroleum pipeline.
Process Control Systems	Controlling a physical process based on monitoring.
Knowledge Domain	Finding out faults in vehicles, computers.
Finance/Commerce	Detection of possible fraud, suspicious transactions, stock market trading, Airline scheduling, cargo scheduling.

4. Discuss about the characteristics of Certainty Factors

Answer) The Certainty Factor (CF) is a numeric value which tells us about how likely an event or a statement is supposed to be true. It is somewhat similar to what we define in probability, but the difference in it is that an agent after finding the probability of any event to occur cannot decide what to do. Based on the probability and other knowledge that the agent has, this certainty factor is decided through which the agent can decide whether to declare the statement true or false.
The value of the Certainty factor lies between -1.0 to +1.0, where the negative 1.0 value suggests that the statement can never be true in any situation, and the positive 1.0 value defines that the statement can never be false. The value of the Certainty factor after analyzing any situation will either be a positive or a negative value lying between this range. The value 0 suggests that the agent has no information about the event or the situation.

5. Discuss about the Advantages/Disadvantages of Certainty Factors

Answer) The Advantages of CF formalism are:

1. It is a simple computational model that permits experts to estimate their confidence in the conclusion being drawn.
2. It permits the expression of belief and disbelief in each hypothesis, allowing the expression of the effect of multiple sources of evidence.
3. It allows knowledge to be captured in a rule representation while allowing the quantification of uncertainty.
4. The gathering of the CF values is significantly easier than the gathering of values for the other methods. No statistical base is required - you merely have to ask the expert for the values.

The disadvantages/criticisms of CF are:

1. The CF lacks theoretical foundation. Basically, the CF were partly **ad hoc**. It is an approximation of probability theory.
2. Non-independent evidence can be expressed and combined only by “chunking” it together within the same rule. When large quantities of non-independent evidence must be expressed, this proves to be unsatisfactory.
3. The CF values could be the opposite of conditional probabilities.
4. The knowledge described within the rule contributes much more to the final, derived results than the CF values

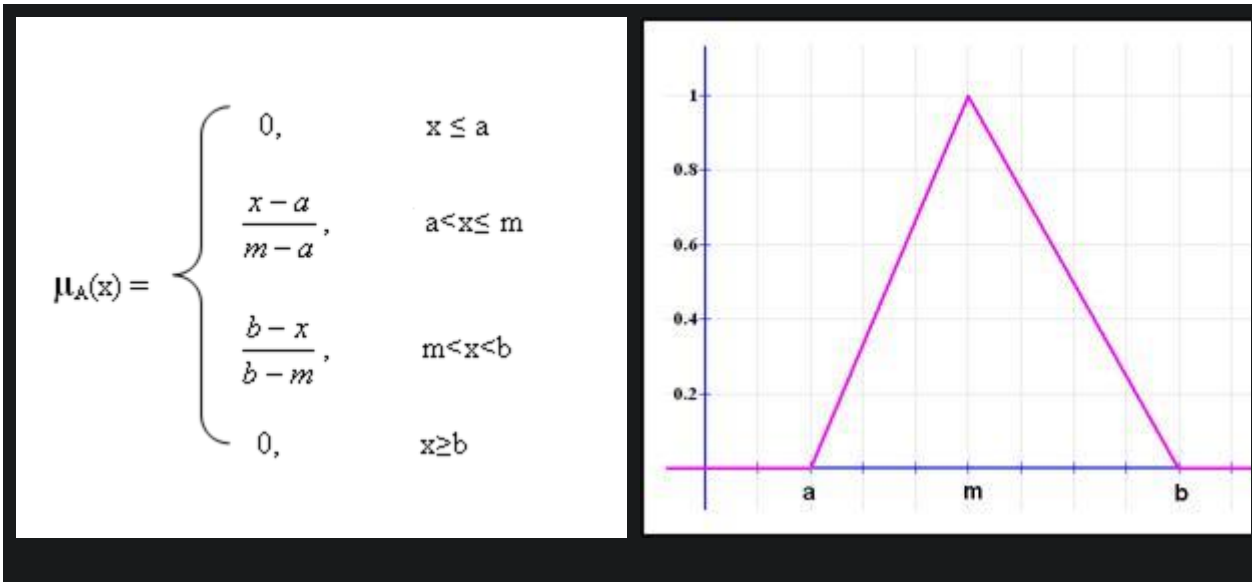
6. Discuss the ways for obtaining the best membership function based on the type of data used?

Answer) The type of membership function that you use is dependent on the type of your input data. Depending on the input parameters and its value, you can select a particular type of membership function. For a very chaotic data, like a time series, you can use a gaussian or bell MF. For data that is not very chaotic, a triangular or trapezoidal MF can be used. Accordingly, your output MF will also change based on the type of input MF and type of FIS you use.

7. How is the membership function value known in fuzzy logic?

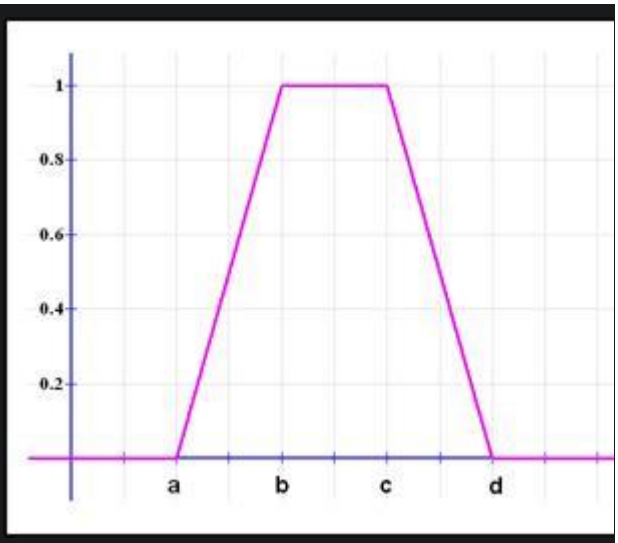
Answer) A membership function for a fuzzy set A on the universe of discourse X is defined as $\mu_A: X \rightarrow [0,1]$, where each element of X is mapped to a value between 0 and 1. This value, called membership value or degree of membership, quantifies the grade of membership of the element in X to the fuzzy set A.
Membership functions allow us to graphically represent a fuzzy set. The x axis represents the universe of discourse, whereas the y axis represents the degrees of membership in the [0,1] interval.
Simple functions are used to build membership functions. Because we are defining fuzzy concepts, using more complex functions does not add more precision.
Below is a list of the membership functions we will use in the practical section of this tutorial.

Triangular function: defined by a lower limit a, an upper limit b, and a value m, where a < m < b.



Trapezoidal function: defined by a lower limit a, an upper limit d, a lower support limit b, and an upper support limit c, where a < b < c < d.

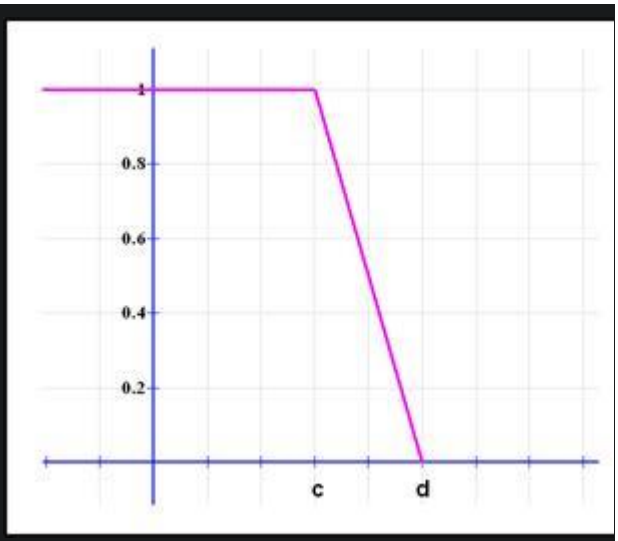
$$\mu_A(x) = \begin{cases} 0, & (x < a) \text{ or } (x > d) \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \end{cases}$$



There are two special cases of a trapezoidal function, which are called R-functions and L-functions:

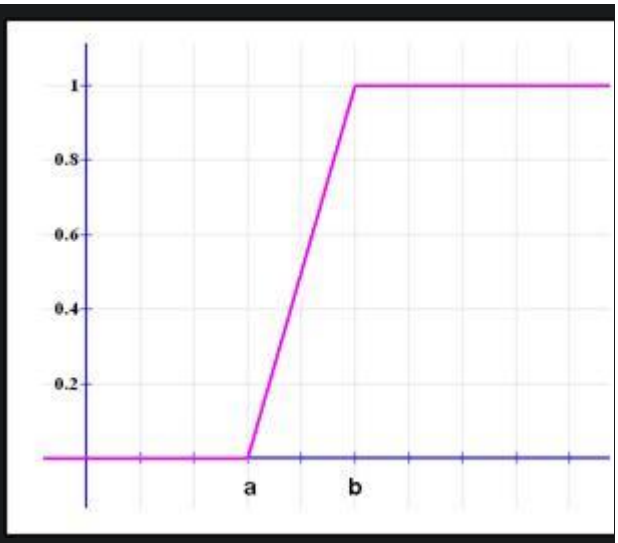
- R-functions: with parameters a = b = - ∞

$$\mu_A(x) = \begin{cases} 0, & x > d \\ \frac{d-x}{d-c}, & c \le x \le d \\ 1, & x < c \end{cases}$$



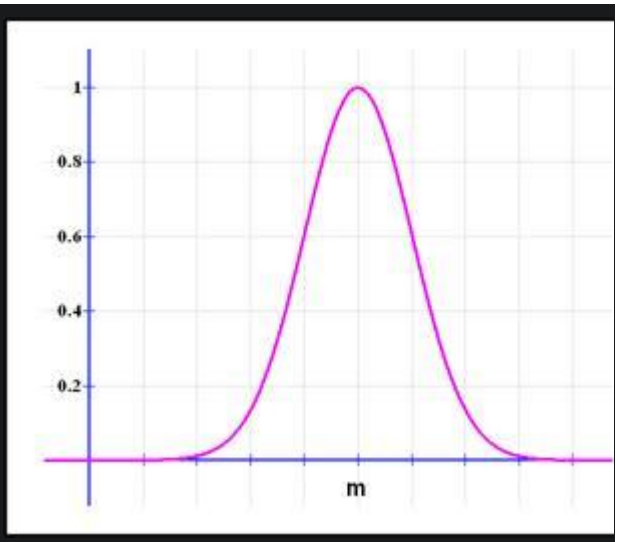
- L-Functions: with parameters c = d = + ∞

$$\mu_A(x) = \begin{cases} 0, & x < a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & x > b \end{cases}$$



Gaussian function: defined by a central value m and a standard deviation k > 0. The smaller k is, the narrower the “bell” is.

$$\mu_A(x) = e^{-\frac{(x-m)^2}{2k^2}}$$



8. Explain the main features of R1 expert system

Answer) XCON/R1 is one of the most cited expert systems. It was developed by DEC (Digital Equipment Corporation) and was a system that ensured the customer was supplied with all the components and software that was needed to make up the specified computer system that they had ordered.

This is not as easy as it sounds. Building a bespoke computer system means that every system is different and, as such, needs different components and software. For example, if a customer orders a disc drive then DEC has to ensure that the customer also receives the disc controller and the relevant cables.

As a single system can be built from thousands of separate components, it was not easy for a human to ensure that the customer had everything he/she needed to build the system.

XCON/R1 was an expert system that did this job automatically. It saved DEC millions of dollars a year and raised the profile of expert system to a level that had not been seen before