2.1 ACTING UNDER UNCERTAINTY

Uncertainty is a situation which involves imperfect and/or unknown information. However, "uncertainty is an unintelligible expression without a straightforward description.

Uncertainty can also arise because of incompleteness, incorrectness in agents understanding the properties of environment.

So to represent uncertain knowledge, where we are not sure about the predicates, we need uncertain reasoning or probabilistic reasoning.

Causes of uncertainty:

Following are some leading causes of uncertainty to occur in the real world.

1. Information occurred from unreliable sources.
2. Experimental Errors
3. Equipment fault
4. Temperature variation
5. Climate change.

Probabilistic reasoning:

Probabilistic reasoning is a way of knowledge representation where we apply the concept of probability to indicate the uncertainty in knowledge. In probabilistic reasoning, we combine probability theory with logic to handle the uncertainty.

We use probability in probabilistic reasoning because it provides a way to handle the uncertainty that is the result of someone's laziness and ignorance.

In the real world, there are lots of scenarios, where the certainty of something is not confirmed, such as "It will rain today," "behavior of someone for some situations," "A match between two teams or two players." These are probable sentences for which we can assume that it will happen but not sure about it, so here we use probabilistic reasoning.

A **certainty factor (CF)** is a numerical value that expresses a degree of subjective belief

that a particular item is true. The item may be a fact or rule.

Suppose that a certainty is defined to be a real number between -1.0 and +1.0, where 1.0 represents complete certainty that an item is true and -1.0 represents complete certainty that an item is false. Here a CF of 0.0 indicates that no information is available about either the truth or the falsity of an item. Hence positive values indicate a degree of belief or evidence that an item is true, and negative values indicate the opposite belief.

Ad-hoc methods of dealing with uncertainty are methods which have no formal theoretical basis.

Ad-hoc procedures are implemented in the MYCIN system. It is the expert systems developed to diagnose meningitis and infectious blood disease.

MYCIN

Its knowledge base is composed of if.. ..then rules which are used to assess various forms of patient evidence with the ultimate goal being the formulation of a correct diagnosis and recommendation for a suitable therapy.

A typical rule has the form:

IF: The stain of the organism is gram positive, and

The morphology of the organism is Coccus, and

The growth conformation of the organism is chains

THEN: There is suggestive evidence (0.7) that the identity of the organism is streptococcus.

Rule-Implication;

- The rule is used by the inference mechanism to help identify the offending organism.
- The 3 conditions given in the IF part of the rule refer to attributes that help to characterize and identify organisms.
- When identification is certain, an appropriate therapy is recommended.
- The numeric value (0.7) given in the THEN part of the above rule corresponds to an experts

estimate of degree of belief one can place in the rule conclusion when the three conditions if the IF part have been satisfied.

- The Belief associated with the rule may be thought of as a conditional probability.

P (H/E1,E2,E3) =0.7

Where H is the hypothesis that the organism is streptococcus, and E1, E2 and E3 correspond to the three pieces of joint evidence given in the IF part, respectively.

MYCIN - Belief and Disbelief :

- MYCIN uses measures of both belief and disbelief to represent degrees of confirmation and disconfirmations respectively in a given hypothesis.
- The measure of belief denoted by MB (H,E) is a measure of the increased belief in hypothesis H due to the evidence E.
- Its equivalent to the estimated increase in probability of P(H/E) over P(H) given by an expert as a result of the knowledge gained by E.
- A value of 0 corresponds to no increase in belief and 1 corresponds to maximum increase or absolute belief.
- MD(H,E) is a measure of the increased disbelief in hypothesis H due to evidence E.
- MD ranges from 0 to +1, with +1 representing maximum increase in disbelief 0 representing no increase.
- In both measures, the evidence E may be absent or may be placed with another hypothesis, MB(H1,H2). This represents the increased belief in H1 given H2 is true.

Uncertainty measure - MYCIN:

MB and MD given in terms of prior and conditional probabilities.

The actual values are subjective probability estimates provided by a physician.

$$MB(H,E) = \begin{cases} 1 & \text{if } P(H) = 1 \\ \frac{\max[P(H|E),P(H)] - P(H)}{\max[1,0] - P(H)} & \text{Otherwise} \end{cases}$$

$$MD(H,E) = \begin{cases} 1 & \text{if } p(H) = 0 \\ \frac{\min[P(H|E),P(H)] - P(H)}{\max[1,0] - P(H)} & \text{Otherwise} \end{cases}$$

Note that when 0 < P(H) <1, and E and H are independent (so P(H|E)=P(H), then MB =MD=0.This would be the case if E provided no useful information.

The two measures MB and MD are combined into a single measure called the certainty factor (CF), denoted by

CF(H,E) =MB(H,E) - MD(H,E)

Note that the value of CF ranges from -1 (certain disbelief) to +1(certain belief). Furthermore, a value of CF=0 will result if E neither confirm nor unconfirms H(E and H are independent).

In MYCIN, each rule hypothesis Hi has an associated MB and MD initially set to 0,

- Evidence are accumulated, they are updated using intermediate combining functions, and when all applicable rules have been executed, a final CF is calculated for each H_i
- These are then compared and the largest cumulative confirmations or disconfirmations are used to determine the appropriate therapy.
- A threshold value of |CF| > 0.2 is used to prevent the acceptance of a weakly supported hypothesis.
- In the initial assignment of belief values an expert will consider all available confirming and disconfirming evidences E1, E2, ... EK and assign properties, consistent values to

both.