1. Provide an example of the concepts of Prior, Posterior, and Likelihood.

2. What role does Bayes' theorem play in the concept learning principle?

3. Offer an example of how the Nave Bayes classifier is used in real life.

4. Can the Nave Bayes classifier be used on continuous numeric data? If so, how can you go about doing it?

5. What are Bayesian Belief Networks, and how do they work? What are their applications? Are they capable of resolving a wide range of issues?

6. Passengers are checked in an airport screening system to see if there is an intruder. Let I be the random variable that indicates whether someone is an intruder I = 1) or not I = 0), and A be the variable that indicates alarm I = 0). If an intruder is detected with probability P(A = 1|I = 1) = 0.98 and a non-intruder is detected with probability P(A = 1|I = 0) = 0.001, an alarm will be triggered, implying the error factor. The likelihood of an intruder in the passenger population is P(I = 1) = 0.00001. What are the chances that an alarm would be triggered when an individual is actually an intruder?

7. An antibiotic resistance test (random variable T) has 1% false positives (i.e., 1% of those who are not immune to an antibiotic display a positive result in the test) and 5% false negatives (i.e., 1% of those who are not resistant to an antibiotic show a positive result in the test) (i.e. 5 percent of those actually resistant to an antibiotic test negative). Assume that 2% of those who were screened were antibiotic-resistant. Calculate the likelihood that a person who tests positive is actually immune (random variable D).

8. In order to prepare for the test, a student knows that there will be one question in the exam that is either form A, B, or C. The chances of getting an A, B, or C on the exam are 30 percent, 20%, and 50 percent, respectively. During the planning, the student solved 9 of 10 type A problems, 2 of 10 type B problems, and 6 of 10 type C problems.

1. What is the likelihood that the student can solve the exam problem?

2. Given the student's solution, what is the likelihood that the problem was of form A?

9. A bank installs a CCTV system to track and photograph incoming customers. Despite the constant influx of customers, we divide the timeline into 5 minute bins. There may be a customer coming into the bank with a 5% chance in each 5-minute time period, or there may be no customer (again, for simplicity, we assume that either there is 1 customer or none, not the case of multiple customers). If there is a client, the CCTV will detect them with a 99 percent probability. If there is no customer, the camera can take a false photograph with a 10% chance of detecting movement from other objects.

1. How many customers come into the bank on a daily basis (10 hours)?

2. On a daily basis, how many fake photographs (photographs taken when there is no customer) and how many missed photographs (photographs taken when there is a customer) are there?

3. Explain likelihood that there is a customer if there is a photograph?

10. Create the conditional probability table associated with the node Won Toss in the Bayesian Belief network to represent the conditional independence assumptions of the Nave Bayes classifier for the match winning prediction problem in Section 6.4.4.

ANSWER:

1. An example of Prior, Posterior, and Likelihood: Suppose you are a doctor trying to diagnose a patient's illness. Your prior probability is your initial estimate of the probability of the patient having a particular illness based on your prior knowledge and experience. The likelihood is the probability of the observed symptoms given the patient has the illness. The posterior probability is the updated probability of the patient having the illness after taking into account the observed symptoms.
2. Bayes' theorem plays a crucial role in the concept learning principle as it enables us to update our beliefs about a concept based on new evidence. The theorem provides a way to calculate the posterior probability of a hypothesis given the data we observe, by combining the prior probability of the hypothesis and the likelihood of the data given the hypothesis.
3. An example of how the Nave Bayes classifier is used in real life is in email spam filtering. The classifier can be trained on a set of labeled examples, where the email is either spam or not spam, and then used to classify new emails as either spam or not spam based on the presence or absence of certain keywords or features in the email.
4. Yes, the Nave Bayes classifier can be used on continuous numeric data. One way to do this is to discretize the data into bins and then treat each bin as a categorical variable. Another way is to assume a probability distribution for the continuous variable, such as a Gaussian distribution, and then use Bayes' theorem to calculate the posterior probability.
5. Bayesian Belief Networks (BBNs) are graphical models that represent the joint probability distribution of a set of random variables and their conditional dependencies using a directed acyclic graph. BBNs work by propagating information from the observed variables to the unobserved variables, allowing us to make probabilistic predictions or decisions. BBNs have applications in various fields, such as medical diagnosis, risk analysis, and decision making.
6. The probability of an alarm being triggered when an individual is actually an intruder can be calculated using Bayes' theorem as follows:

P(I = 1|A = 1) = P(A = 1|I = 1) \* P(I = 1) / [P(A = 1|I = 1) \* P(I = 1) + P(A = 1|I = 0) \* P(I = 0)] = 0.98 \* 0.00001 / [0.98 \* 0.00001 + 0.001 \* 0.99999] ≈ 0.0097 or about 1%.

1. The likelihood that a person who tests positive is actually immune can be calculated using Bayes' theorem as follows:

P(D = 1|T = 1) = P(T = 1|D = 1) \* P(D = 1) / [P(T = 1|D = 1) \* P(D = 1) + P(T = 1|D = 0) \* P(D = 0)] = 0.95 \* 0.02 / [0.95 \* 0.02 + 0.01 \* 0.98] ≈ 0.66 or about 66%.

1. 1. To find the likelihood that the student can solve the exam problem, we need to use Bayes' theorem. Let A be the event that the problem is of form A, and S be the event that the student can solve the problem. We want to find P(S), the probability that the student can solve the problem. We have the following information:

P(A) = 0.3, P(B) = 0.2, P(C) = 0.5 P(S|A) = 0.9, P(S|B) = 0.2, P(S|C) = 0.6

Using the law of total probability, we can find the probability that the problem can be solved:

P(S) = P(S|A)P(A) + P(S|B)P(B) + P(S|C)P(C) = 0.9(0.3) + 0.2(0.2) + 0.6(0.5) = 0.51

Therefore, the likelihood that the student can solve the exam problem is 0.51 or 51%.

1. To find the likelihood that the problem was of form A given the student's solution, we need to use Bayes' theorem again. Let S be the event that the student can solve the problem, and A be the event that the problem is of form A. We want to find P(A|S), the probability that the problem was of form A given that the student can solve it. We have the following information:

P(A) = 0.3, P(B) = 0.2, P(C) = 0.5 P(S|A) = 0.9, P(S|B) = 0.2, P(S|C) = 0.6

Using Bayes' theorem, we have:

P(A|S) = P(S|A)P(A) / P(S) = (0.9)(0.3) / 0.51 = 0.529

Therefore, the likelihood that the problem was of form A given the student's solution is 0.529 or 52.9%.

* 1. The probability that a customer comes into the bank in a 5-minute time period is 0.05. There are 6 such periods in an hour and 60 periods in 10 hours. Therefore, the expected number of customers in 10 hours is:

0.05 \* 6 \* 60 = 18

So, on average, 18 customers come into the bank in 10 hours.

1. If there is no customer, the camera can take a false photograph with a probability of 0.1. If there is a customer, the camera will detect them with a probability of 0.99. Let's denote the event that a customer comes into the bank by C, and the event that a photograph is taken by P. Then, the expected number of fake photographs and missed photographs in 10 hours can be calculated as follows:

Expected number of fake photographs = P(~C) \* P(P|~C) \* 10 \* 60 = (1 - 0.05) \* 0.1 \* 10 \* 60 = 30

Expected number of missed photographs = P(C) \* P(~P|C) \* 10 \* 60 = 0.05 \* (1 - 0.99) \* 10 \* 60 = 3

Therefore, on average, there are 30 fake photographs and 3 missed photographs in 10 hours.