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Practical 3

Bayes's Theorem

- **Definition :** Write a program which scans value of k where k indicates number of mutually exclusive and exhaustive events (E1,E2,...,Ek). Assume any another event B. Implement BaEe's theorem assuming these k events assuming that the event B to estimate the probability of each of the k events assuming that the event B is already occurred (i.e. p(E1|B),....P(Ek|B)) your program should also scan probability of each of the k or k-1 events and probability fo occurrence of event B assuming that each of the k events has occurred.

- **Formula :**

$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}$$

- **Example :**

Box P has 2 red balls and 3 blue balls and box Q has 3 red balls and 1 blue ball. A ball is selected as follows:

(i) Select a box

(ii) Choose a ball from the selected box such that each ball in the box is equally likely to be chosen. The probabilities of selecting boxes P and Q are (1/3) and (2/3), respectively.

Given that a ball selected in the above process is a red ball, What is the probability that it was came from the box P ?

Solution :

R $\longrightarrow$ Event that red ball is selected

B $\longrightarrow$ Event that blue ball is selected

P $\longrightarrow$ Event that box P is selected

Q $\longrightarrow$ Event that box Q is selected

We need to calculate P(P|R) :

$$P(P|R) = \frac{P(R|P)\,P(P)}{P(R)}$$

P(R|P) = A red ball selected from box P

= 2/5

P(P) = 1/3

P(R) = P(P)*P(R|P) + P(Q)*P(R|Q)

= (1/3)*(2/5) + (2/3)*(3/4)

= 2/15 + 1/2

= 19/30

Putting above values in the Bayes's Formula

P(P|R) = (2/5)*(1/3) / (19/30)

= 4/19

- **Code :**

```python
import array as arr
k = int(input("\nEnter the number of mutually exclusive and exhaustive events (k) : "))
events = arr.array('d')      # stores P(E1),P(E2),P(E3),...P(Ek)
print("\nEnter probability of each of the", k , "events : ")
for event in range(0,k):
    print("\tFor event",event+1,": ",end="")
    events.append(float(input()));
conditional_events = arr.array('d')      # stores P(B|E1),P(B|E2),P(B|E3),...P(B|Ek)
print("\nEnter probability of occurrence of event B assuming that each  of the", k , "events has occurred : ")
for conditional_event in range(0,k):
    print("\tFor event",conditional_event+1,": ",end="")

    conditional_events.append(float(input()));
p_of_B = 0;
for index in range(0,k):
    p_of_B += conditional_events[index]*events[index]
print("Probability calculated through Bayes's theorem : ")
for index in range(0,k):
    print("\tP(E{}|B) = {}".format(index+1,round((conditional_events[index]*events[index])/p_of_B,2)))
```

- **Sample I/O :**

```
Enter the number of mutually exclusive and exhaustive events (k) : 2

Enter probability of each of the 2 events :
    For event 1 : .33
    For event 2 : .66

Enter probability of occurrence of event B assuming that each  of
    the 2 events has occurred :
    For event 1 : .4
    For event 2 : .75
Probability calculated through Bayes's theorem :
    P(E1|B) = 0.21
    P(E2|B) = 0.79

Run Succeeded | Time 33 ms | Peak Memory 5.7M        Symbol | Tabs: 4 | Line 18, Column 103
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