PRINCIPLE OF BIOLOGICAL VISION

Assignment-2: Implementation of Bayesian Network

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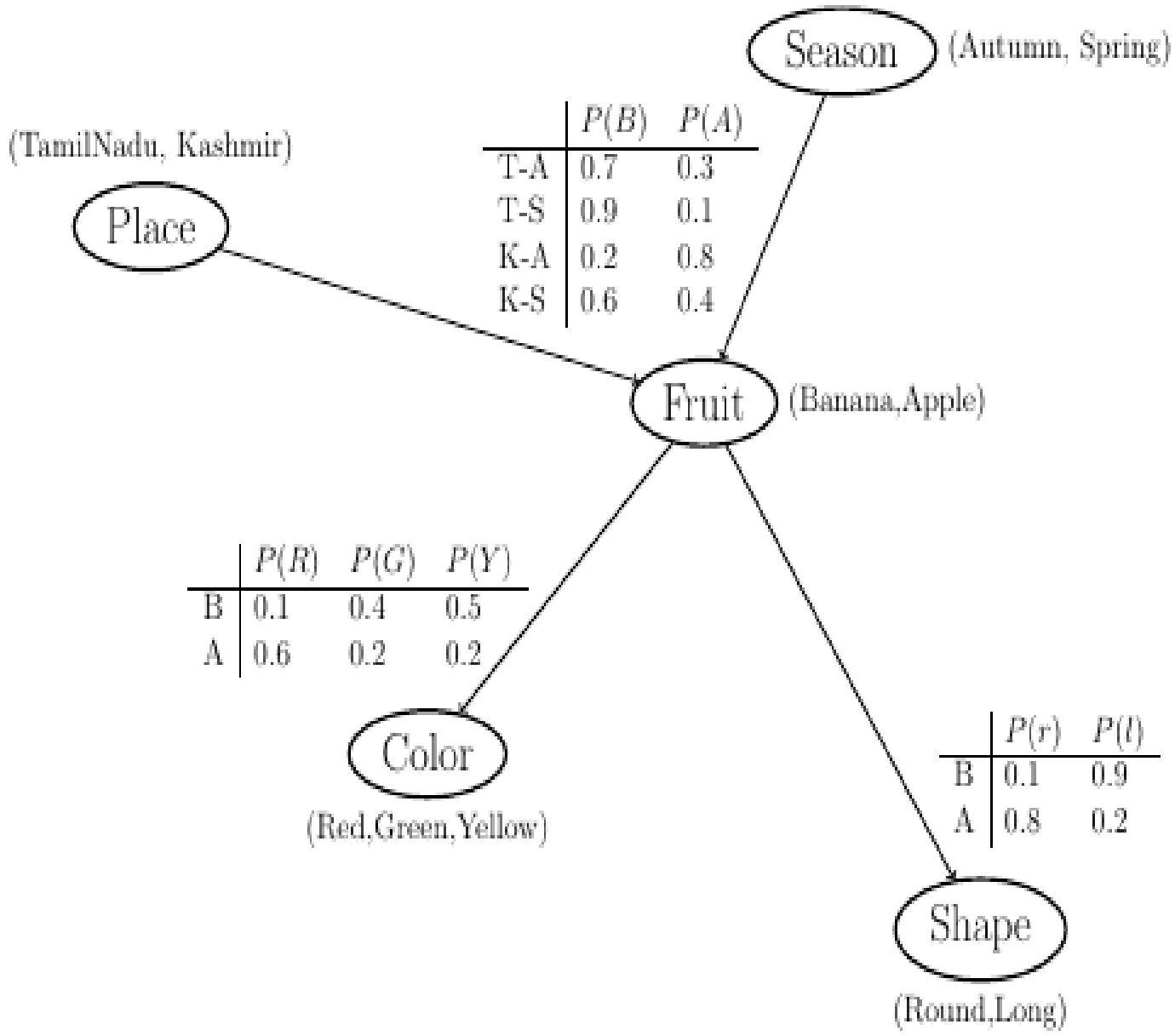
Google Colab Link:
https://colab.research.google.com/drive/17CYJh6XX7hIaMMnIGy2XWdj-aNKNQ1SF?usp=sharing

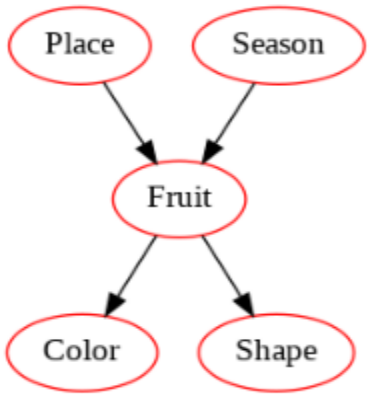


	$P(B)$	$P(A)$
T-A	0.7	0.3
T-S	0.9	0.1
K-A	0.2	0.8
K-S	0.6	0.4

	$P(R)$	$P(G)$	$P(Y)$
B	0.1	0.4	0.5
A	0.6	0.2	0.2

	$P(r)$	$P(l)$
B	0.1	0.9
A	0.8	0.2

1. **Set prior probabilities for places as P(T) = P(K) = 0.5 and those for the seasons as P(A) = P(S) = 0.5. The equiprobable states mean that we do not know at which place we are, and which season we are in. Compute the prior probabilities for and determine the most likely fruit, color, and shape.**
   Result:



Prior Probabilities

```
P(Kashmir): 0.5
P(TamilNadu): 0.5

P(Autumn): 0.5
P(Spring): 0.5

P(Apple): 0.4
P(Banana): 0.6

P(Red): 0.3
P(Green): 0.32
P(Yellow): 0.38

P(Round): 0.38
P(Long): 0.62
```

```
Most Likely Fruit: Banana
Most Likely Color: Yellow
Most Likely Shape: Long
```

My Findings:

The Prior Marginal Probabilities of Fruit, Color, and Shape depends upon the initial prior probability of Place and Season

2. **Now assume that you are in Kashmir. Instantiate the "place" node accordingly (set appropriate probability values). Compute the posterior probabilities.**
   Result:
   Posterior Probabilities

```
P(Kashmir): 1
P(TamilNadu): 0

P(Autumn): 0.5
P(Spring): 0.5

P(Apple): 0.6
P(Banana): 0.4

P(Red): 0.4
P(Green): 0.28
P(Yellow): 0.32

P(Round): 0.52
P(Long): 0.48
```

   My Findings:
   The Prior Marginal Probabilities of Fruit, Color, and Shape depends upon the initial prior probability of Place and Season
   As we change the Prior Probability of Place i.e P(Kashmir)=1 the posterior probability of Fruit, Color and Shape changes as they are conditionally dependent on the Place. But the posterior probability of season does not change since Place and Season are conditionally independent.

3. ***Suggestion: Hand computes results of steps 1 and 2 and compare to verify the Bayesian network is correctly implemented.***

Solution:

Step1:

A. Calculating Prior Probabilities

Given:

P(Kashmir)=P(TamilNadu)=0.5

P(Autumn)=P(Spring)=0.5

- Calculating Prior probabilities for Fruit

  Let,

  T=TamilNadu

  K=Kashmir

  A=Autumn

  S=Spring

  P(Apple) =

  P(Apple|T-A)*P(T)*P(A)+P(Apple|T-S)*P(T)*P(S)+P(Apple|K-A)*P(K)*P(A)+P(Apple|K-S)*P(K)*P(S)

  P(Apple) = 0.3*0.5*0.5+0.1*0.5*0.5+0.8*0.5*0.5+0.4*0.5*0.5

  P(Apple) = 0.4

  P(Banana) =

  P(Banana|T-A)*P(T)*P(A)+P(Banana|T-S)*P(T)*P(S)+P(Banana|K-A)*P(K)*P(A)+P(Banana|K-S)*P(K)*P(S)

  P(Banana) = 0.7*0.5*0.5+0.9*0.5*0.5+0.2*0.5*0.5+0.6*0.5*0.5

  P(Banana) = 0.6

- Calculating Prior probabilities for Color

  P(Red)=P(Red|Apple)*P(Apple) + P(Red|Banana)*P(Banana)

  P(Red)=0.6*0.4+0.1*0.6

  P(Red)=0.3

  P(Green)=P(Green|Apple)*P(Apple) + P(Green|Banana)*P(Banana)

  P(Green)=0.2*0.4+0.4*0.6

  P(Green)=0.32

  P(Yellow)=P(Yellow|Apple)*P(Apple) + P(Yellow|Banana)*P(Banana)

  P(Yellow)=0.2*0.4+0.5*0.6

  P(Yellow)=0.38

- Calculating Prior probabilities for Shape

P(Round)=P(Round|Apple)*P(Apple) + P(Round|Banana)*P(Banana)
P(Round)=0.8*0.4+0.1*0.6
P(Round)=0.38

P(Long)=P(Long|Apple)*P(Apple) + P(Long|Banana)*P(Banana)
P(Long)=0.2*0.4+0.9*0.6
P(Long)=0.62

B. Finding Most likely Fruit, Color, and Shape
The Most likely Fruit is Banana since P(Banana) > P(Apple)
The Most likely Color is Yellow since P(Yellow) > P(Green)>P(Red)
The Most likely Shape is Long since P(Long) > P(Round)

Step2:
Assuming it is Kashmir.
P(K)=1, P(T)=0

A. Calculating Posterior Probability
- Calculating Posterior probabilities for Fruit

Let,

T=TamilNadu
K=Kashmir
A=Autumn
S=Spring
P(Apple) =
P(Apple|T-A)*P(T)*P(A)+P(Apple|T-S)*P(T)*P(S)+P(Apple|K-A)*P(K)*P(A)
+P(Apple|K-S)*P(K)*P(S)
P(Apple) = 0.3*0*0.5+0.1*0*0.5+0.8*1*0.5+0.4*1*0.5
P(Apple) = 0.6

P(Banana) =
P(Banana|T-A)*P(T)*P(A)+P(Banana|T-S)*P(T)*P(S)+P(Banana|K-A)*P(K
)*P(A)+P(Banana|K-S)*P(K)*P(S)
P(Banana) = 0.7*0*0.5+0.9*0*0.5+0.2*1*0.5+0.6*1*0.5
P(Banana) = 0.4

- Calculating Posterior probabilities for Color

P(Red)=P(Red|Apple)*P(Apple) + P(Red|Banana)*P(Banana)
P(Red)=0.6*0.6+0.1*0.4
P(Red)=0.4
P(Green)=P(Green|Apple)*P(Apple) + P(Green|Banana)*P(Banana)
P(Green)=0.2*0.6+0.4*0.4
P(Green)=0.28

P(Yellow)=P(Yellow|Apple)*P(Apple) + P(Yellow|Banana)*P(Banana)
P(Yellow)=0.2*0.6+0.5*0.4
P(Yellow)=0.32

- Calculating Posterior probabilities for Shape
  P(Round)=P(Round|Apple)*P(Apple) + P(Round|Banana)*P(Banana)
  P(Round)=0.8*0.4+0.1*0.6
  P(Round)=0.52

  P(Long)=P(Long|Apple)*P(Apple) + P(Long|Banana)*P(Banana)
  P(Long)=0.2*0.6+0.9*0.4
  P(Long)=0.48

- Calculating Posterior probabilities for Season
  As season and place are conditionally Independent. Therefore the Probabilities of Season won't change
  P(Spring)=0.5
  P(Autumn)=0.5

4. **Check the states of the various nodes. Has anyone remained unchanged? Explain why.**
   Solution:
   The State of Season has remained unchanged since changing the Places (P(Kashmir)=1) results in no change in the Season as Season and Places are conditionally independent and they have no linkages between them.
   But State of Fruits, Colors, and Shapes change since Fruits depends on Places and Season, so change in Place results in the change in Fruits
   Further, Colors and Shapes depends upon Fruits and if the state of Fruits changes it results in the change of Colors and Shapes

5. **Further (keep the "Kashmir" assumption), assume that you are observing a yellow fruit, round in shape. Instantiate the color and the shape nodes accordingly and compute the posterior probabilities of the unobserved nodes in the network.**
Result:

```
P(Kashmir): 1
P(TamilNadu): 0

P(Autumn): 0.59
P(Summer): 0.41

P(Apple): 0.83
P(Banana): 0.17

P(Red): 0
P(Green): 0
P(Yellow): 1

P(Round): 1
P(Long): 0
```

My Findings:
The Probability of Season and Fruits changes while giving Place as Kashmir like earlier, Color as Yellow, Shape as Round. The reason behind this is Fruits and (Color, Shape) are conditionally dependent and Seasons and Fruits are conditionally dependent.

6. **What are the most likely fruit and the most likely season you are in?**
Result:

```
Most Likely Fruit: Apple
Most Likely Season: Autumn
```

My Findings:
The most likely Fruit is Apple since P(Apple)>P(Banana)
The most likely Season is Autumn since P(Autumn)>P(Spring)