

Exercises

Exercise 5.1: Epidemiology

Imagine that you are an epidemiologist and you are determining people's cause of death.

In this simplified world, there are two main diseases, cancer and the common cold.

- People rarely have cancer, $\Pr(\text{Cancer}) = 0.00001$.
- People are much more likely to have a common cold: $\Pr(\text{Cold}) = 0.2$.
- When people do have cancer, it is often fatal: $\Pr(\text{Death} \mid \text{Cancer}, \neg\text{Cold}) = 0.9$.
- Having a cold is rarely fatal: $\Pr(\text{Death} \mid \text{Cold}, \neg\text{Cancer}) = 0.00006$
- But having cancer and a cold is slightly more deadly than having cancer alone: $\Pr(\text{Death} \mid \text{Cold}, \text{Cancer}) = 0.91$.
- Very rarely, people also die of other causes: $\Pr(\text{Death} \mid \neg\text{Cold}, \neg\text{Cancer}) = 0.000000001$.

Write this model in WebPPL and use `Infer` to answer the following questions (Be sure to include your code in your answer):

Question 5.1.1

Compute $\Pr(\text{Cancer} \mid \text{Death}, \text{Cold})$ and $\Pr(\text{Cancer} \mid \text{Death}, \neg\text{Cold})$.

How do these probabilities compare to $\Pr(\text{Cancer} \mid \text{Death})$ and $\Pr(\text{Cancer})$?

Using these probabilities, give an example of explaining away.

```
display("Prior:")
viz.table(
  Infer(
    {method: 'enumerate'},
    function() {
      ...
    }
  )
)
```

```
display("Death:")
viz.table(
  Infer(
    {method: 'enumerate'},
    function() {
      ...
    }
  )
)
```

```
display("Death and Cold:")
viz.table(
  Infer(
    {method: 'enumerate'},
    function() {
      ...
    }
  )
)
```

```
display("Death and No Cold:")
viz.table(
  Infer(
    {method: 'enumerate'},
    function() {
      ...
    }
  )
)
```

Question 5.1.2

Compute $\Pr(\text{Cold} \mid \text{Death}, \text{Cancer})$ and $\Pr(\text{Cold} \mid \text{Death}, \neg\text{Cancer})$.

How do these probabilities compare to $\Pr(\text{Cold} \mid \text{Death})$ and $\Pr(\text{Cold})$?

Using these probabilities, give an example of explaining away.

```
display("Prior:")
viz.table(
  Infer(
    {method: 'enumerate'},
```

```
function() {  
  ...  
}  
)  
)
```

```
display("Death:")  
viz.table(  
  Infer(  
    {method: 'enumerate'},  
    function() {  
      ...  
    }  
  )  
)
```

```
display("Death and Cancer:")  
viz.table(  
  Infer(  
    {method: 'enumerate'},  
    function() {  
      ...  
    }  
  )  
)
```

```
display("Death and No Cancer:")  
viz.table(  
  Infer(  
    {method: 'enumerate'},  
    function() {  
      ...  
    }  
  )  
)
```

Exercise 5.2: Are They Independent?

For each question, determine whether the relevant variables are independent in the given Bayes Net. Here, grey nodes represent *observed* variables while white nodes represent *unobserved* variables.

Question 5.2.1

Are A and B independent?

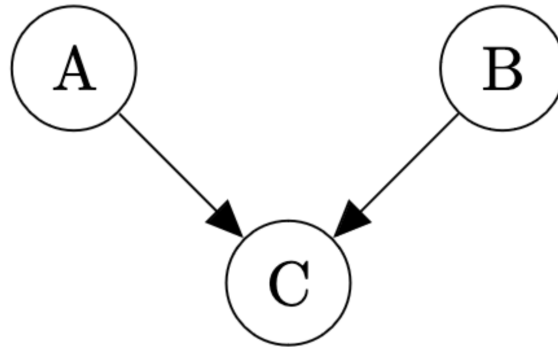


Figure 1: Bayes Net for Question 5.2.1

Question 5.2.2

Are A and B independent?

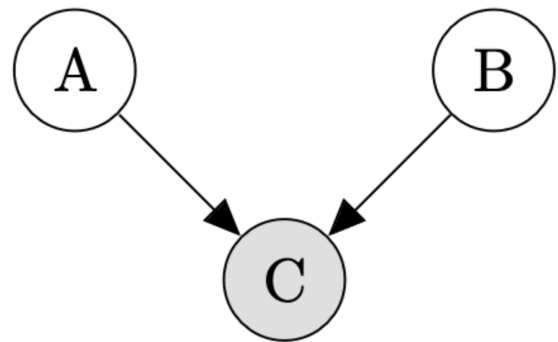


Figure 2: Bayes Net for Question 5.2.2

Question 5.2.3

Are A and C independent?

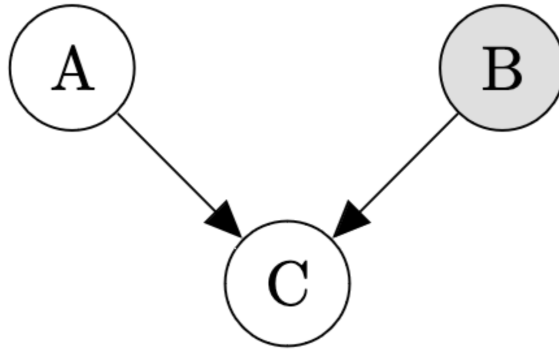


Figure 3: Bayes Net for Question 5.2.3

Question 5.2.4

Are B and C independent?

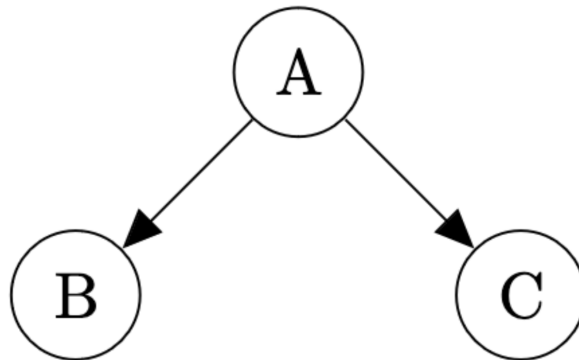


Figure 4: Bayes Net for Question 5.2.4

Question 5.2.5

Are B and C independent?

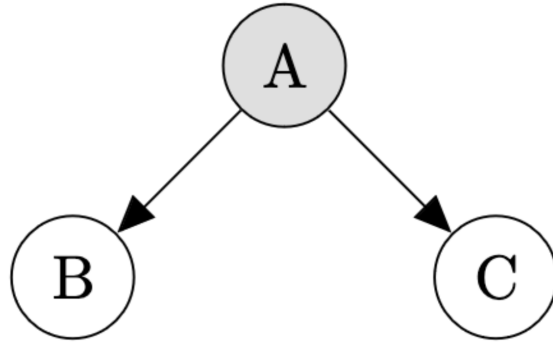


Figure 5: Bayes Net for Question 5.2.5

Question 5.2.6

Are A and B independent?

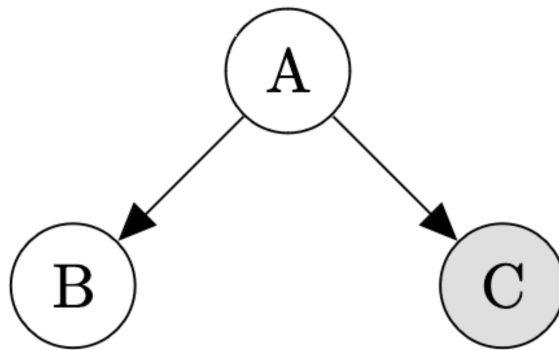


Figure 6: Bayes Net for Question 5.2.6