ROB311 - TD5 - Apprentissage pour la Robotique

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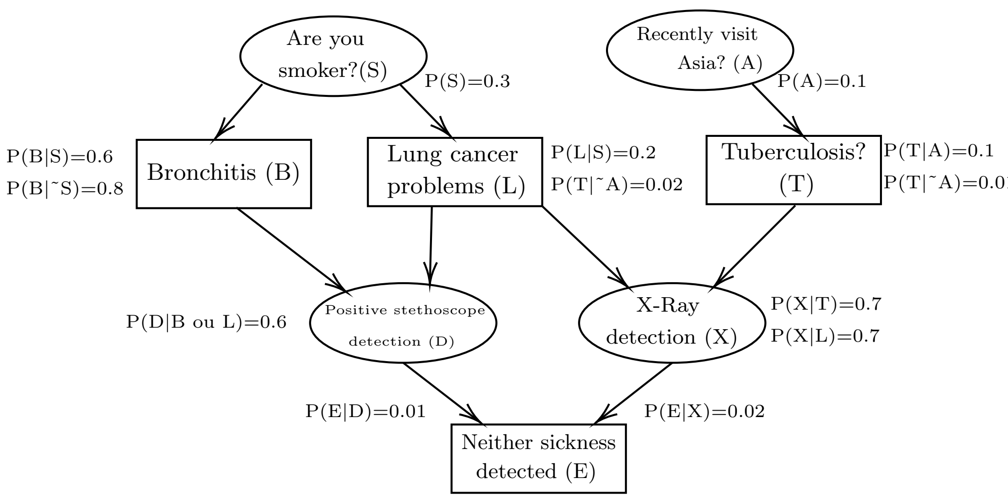
1. Model this problem using a Bayesian network



2. If the patient is not smoking and has not recently visited Asia, can you infer with disease?

The probability of each diseased considering this information's can be modelled by the following three probabilities:

- $P(B \mid S' \ and \ A')$
- $P(L \mid S' \ and \ A')$

- $P(T \mid S' \ and \ A')$

To apply the Bayesian law, one must notice that the events A' and S' are independent and so are S' and T. Consequently, the following is possible:

$$P(B \mid S' \ and \ A') = \frac{P(B \ and \ S' \ and \ A')}{P(S' \ and \ A')} = \frac{P(B \ and \ S')P(A')}{P(S')P(A')} \tag{1}$$

Finally, the result is:

$$P(B \mid S' \ and \ A') = \frac{P(B \mid S')P(S')}{P(S')} = P(B \mid S') = 0{,}8 \tag{2}$$

The same applies to the other two probabilities, therefore the probability of each disease knowing that the patient is neither a smoker nor has gone to Asia is:

- $P(B \mid S' \ and \ A') = 0{,}8$
- $P(L \mid S' \ and \ A') = 0{,}02$
- $P(T \mid S' \ and \ A') = 0{,}01$

Finally, it is possible to infer that the most likely this patient is suffering of bronchitis.

3. According to the disease inferred in Point 2, the doctor decides to auscultate the patient's lungs with a stethoscope? Why?

The doctor normally will decide to auscultate the patient as the diseases which are more likely (Bronchitis and Lung Cancer) can be diagnosed in 60 % of the cases with this method.

3.1. The stethoscope test is negative. What is the new inferred diagnosis?

As the stethoscope detection is negative, the diseases probabilities change. Firstly, we can use the network to get the Probability for a given event, in this case:

- $P(B \mid D')$
- $P(L \mid D')$
- $P(T \mid D')$

Where P(D') is given by:

	P(D')=
B'C'	(0.99)(0.2)(0.98) +
B'C	(0.4)(0.2)(0.02) +
BC'	(0.4)(0.8)(0.98) +
BC	(0.4)(0.8)(0.02) = 0.51564

Applying simply, $P(A \mid B) = \frac{P(B|A)P(A)}{P(B)}$, the result for the probabilities are:

- $P(B \mid D')$

$$P*(B) = P(B \mid D') = \frac{P(D' \mid B)P(B)}{P(D')} = \frac{0{,}4\ 0{,}8}{0{,}51564} = 0{,}6206 \tag{3}$$

- $P(L \mid D')$

$$P*(L) = P(L \mid D') = \frac{P(D' \mid L)P(L)}{P(D')} = \frac{0{,}4\ 0{,}02}{0{,}51564} = 0{,}0155 \tag{4}$$

- $P(T \mid D')$

$$P*(T) = P(T \mid D') = \frac{P(D' \mid T)P(T)}{P(D')} = \frac{P(D')P(T)}{P(D')} = 0{,}01 \tag{5}$$

The new inferred diagnosis is again Bronchitis, now with a smaller probability.

4. The doctor orders an X-Ray. The X-Ray test is positive. What is the new inferred diagnosis?

Firstly, the probability of $P(X)$ must be calculated.

$$\begin{aligned} P(X) =& P(T \text{ } or \text{ } C|A' \text{ } and \text{ } S')P(X|T \text{ } or \text{ } C) \\ &+ P(T' \text{ } and \text{ } C'|A' \text{ } and \text{ } S')P(X|T' \text{ } and \text{ } C') \\ P(X) =& (P(T|A' \text{ } and \text{ } S') + P(C|A' \text{ } and \text{ } S'))P(X|T \text{ } or \text{ } C) \\ &+ P(T'|A' \text{ } and \text{ } S')P(C'|A' \text{ } and \text{ } S')P(X|T' \text{ } and \text{ } C') \\ \therefore P(X) =& (0{,}01 + 0{,}02)0{,}7 + 0{,}99\ 0{,}98\ 0{,}02 = 0{,}04 \end{aligned} \tag{6}$$

Therefore considering the new probabilities calculated for the Bayesian network in Point 3, the new probabilities of each disease is:

- $P(B \mid X)$
- $P(L \mid X)$
- $P(T \mid X)$

Applying simply, the Bayesian law, the results are:

- $P(B \mid X)$

$$P*(B) = P(B \mid X) = \frac{P(X \mid B)P(B)}{P(X)} = \frac{P(X)P(B)}{P(X)} = 0{,}6206 \tag{7}$$

- $P(L \mid D')$

$$P*(L) = P(L \mid X) = \frac{P(X \mid L)P(L)}{P(X)} = \frac{0{,}7\ 0{,}00155}{0{,}04} = 0{,}0027 \tag{8}$$

- $P(T \mid D')$

$$P*(T) = P(T \mid X) = \frac{P(X \mid T)P(T)}{P(X)} = \frac{0{,}7\ 0{,}01}{0{,}04} = 0{,}175 \tag{9}$$

The diagnostic is again Bronchitis.

5. Was the X-Ray needed?

The X-Ray was not needed, as it did not affect the probabilities of the patient having Bronchitis, and it did not offer a 100 % probability of detection of the other diseases. That is, the X-Ray diagnosis would only dismissed the suspicion of the other diseases (cancer and tuberculosis) by reducing its probabilities, never changing the original diagnosis: Bronchitis.