ROB311

Medical diagnosis

T C B

A hospital uses a support system for detecting lung problems. The system is designed to help in the diagnosis of tuberculosis, cancer, and bronchitis.
The system will use previous data from the hospital gathered from previous consultations.

A S

At the registration in the hospital, a new patient it is asked to fill in a questionnaire and answer 2 questions: "Have you recently visited Asia? " and " Are you a smoker? ".

The data shows that: $P(A) = 0.1$ $P(S) = 0.3$

- among all the patients, 10% have recently visited Asia, and 30% are smokers;
- Tuberculosis is present in Asia, and a patient who recently visited Asia has 10% of having tuberculosis and a patient who have not been recently to Asia has only 1% of having tuberculosis; $\rightarrow P(T|A)$ $\rightarrow P(T|\neg A)$
- Patients that smoke and complain of lung problems have 20% of having cancer (against only 2% for patients that do not smoke); $\rightarrow P(C|S)$
- Patients that do not smoke are suffering in 80% of cases of only a bronchitis (against only 60% for people that smoke). $\rightarrow P(B|S)$ $\rightarrow P(B|\neg S)$

The doctor proposes only 2 tests:

- T1 The doctor auscultates the patient's lungs with a stethoscope. A bronchitis or a lung cancer can be detected in 60% of cases. When the patient has none of these two diseases, the doctor will detect it with a probability of 99%; $\rightarrow P(T1|B \cup C)$ $\rightarrow P(T1|\neg B \wedge \neg C)$
- T2 The doctor orders an X-Ray. With the X-Ray the tuberculosis or lung cancer are detected in 70% of cases. If the patient has none of these two diseases, nothing will be observed on the X-Ray with a probability of 98% $\rightarrow P(T2|T \cup C)$ $\rightarrow P(T2|\neg B \wedge \neg C)$

- Marginal Probabilities

$$P(A) = 0.10 \quad , \quad P(S) = 0.3$$

- Conditional Probabilities

$P(T|A) = 0,1$, $P(T|\neg A) = 0,01$

$P(C|S) = 0,2$, $P(C|\neg S) = 0,02$

$P(B|S) = 0,6$, $P(B|\neg S) = 0,8$

- Test Probabities

$P(T1|B \cup C) = 0,6$

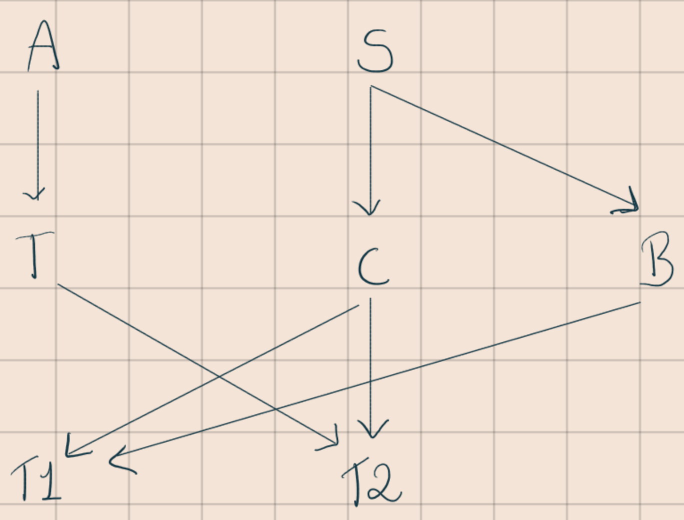
$P(T1|\neg B \wedge \neg C) = 0,01$

$P(T2|T \cup C) = 0,7$

$P(T2|\neg T \wedge \neg C) = 0,02$

Questions:

- Model this problem using a Bayesian network;



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

T/

$P(T \wedge \neg A) = P(\neg A) \cdot P(T \mid \neg A) = 0.9 \times 0.01 = 0.009$

$P(T \wedge \neg A \wedge \neg S) = P(T \wedge \neg A) \cdot P(\neg S) = 0.009 \times 07 = \boxed{0.0063}$

C/

$P(C \wedge \neg S) = P(\neg S) . P(C \mid \neg S) = 0.7 . 0.02 = 0.014$

$P(C \wedge \neg A \neg S) = P(C \mid \neg S) . P(\neg A) = 0.014 . 0.9 = \boxed{0.0126}$

B/

$P(B \wedge \neg S) = P(\neg S) . P(B \mid \neg S) = 0.7 . 0.8 = 0.56$

$P(B \wedge \neg A \neg S) = P(B \mid \neg S) . P(\neg A) = 0.56 . 0.9 = \boxed{0.504}$

None/

$P(N) = 1 - [P(T) + P(B) + P(C)] = \boxed{0.4771}$

- According to the disease inferred in Point 2, the doctor decides to auscultate the patient's lungs with a stethoscope? Why?
The stethoscope test is negative. What is the new inferred diagnosis?

$P(N) \to$ none desease

→ Both can be detected in 60% of the cases, plus Bronchitis is the most probable disease

$$
\begin{cases}
P(T \mid \neg A \wedge \neg S) \cdot P(\neg T1 \mid T) = 0.0063 \cdot 1 = 0.0063 \\
P(C \mid \neg A \wedge \neg S) \cdot P(\neg T1 \mid C) = 0.0126 \cdot 0.4 = 0.00504 \\
P(B \mid \neg A \wedge \neg S) \cdot P(\neg T1 \mid B) = 0.504 \cdot 0.4 = 0.2016 \\
P(N \mid \neg A \wedge \neg S) \cdot P(\neg T1 \mid N) = 0.4771 \cdot 0.99 = 0.47233
\end{cases}
$$

$\sum P() = 0.68527$

- Normalizing:

$P(T \mid \neg T1) = 0.0063 / 0.68527 \simeq 0.0092$

$P(B \mid \neg T1) = 0.00504 / 0.68527 \simeq 0.0074$

$P(C \mid \neg T1) = 0.2016 / 0.68527 \simeq 0.2943$

$P(N \mid \neg T1) = 0.47233 / 0.68527 \simeq 0.6891$

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

1) $P(T2 \mid T) = 0{,}7$

$P(T2 \mid C) = 0{,}7$

$P(T2 \mid \neg T \wedge \neg C) = 0{,}02$

II)
$$
\sum
\begin{cases}
P(T \wedge T2) = P(T \mid \neg T1) \cdot P(T2 \mid T) = 0.0092 \cdot 0.7 = 0.00644 \\
P(C \wedge T2) = P(C \mid \neg T1) \cdot P(T2 \mid C) = 0.0074 \cdot 0.7 = 0.00518 \\
P(B \wedge T2) = P(B \mid \neg T1) \cdot P(T2 \mid B) = 0.2943 \cdot 0 = 0 \\
P(N \wedge T2) = P(N \mid \neg T1) \cdot P(T2 \mid N) = 0.6891 \cdot 0.02 = 0.013782
\end{cases}
$$

Sum $= 0.025402$

III) Normalizing

$P(T \mid T2) = \frac{0.00644}{Sum} = 0.2536$

$P(B \mid T2) = \frac{0}{Sum} = \emptyset$

$P(N \mid T2) = \frac{0.013782}{Sum} = 0.5424$

$P(C \mid T2) = \frac{0.00518}{Sum} = 0.2040$

- Was the X-Ray needed?

The X-Ray was needed to ensure a through and accurate diagnosis, as its significantly increased the probabilities of detecting critical conditions like tuberculosis and cancer.