Exercise 16

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a)

$P(S \cap W) = P(W \cap S)$ I

$P(S \cap W) = P(S)\,P(W|S)$ II

$P(W \cap S) = P(W)\,P(S|W)$ III

I states that II = III

$\Rightarrow P(W)\,P(S|W) = P(S)\,P(W|S)$

$\Leftrightarrow P(S|W) = \dfrac{P(W|S) \cdot P(S)}{P(W)}$

b)

$P(S) = \dfrac{\text{Times soccer was played}}{\text{was played + was not played}} = \dfrac{9}{14}$

$P(W|S) = \prod_i P(x_i|S)$ $\qquad P(x_i|S) = P(S \cap x_i) : P(S)$

$P(\text{wind} = \text{high} \mid S = \text{yes}) = \dfrac{P(S=\text{yes}, \text{wind} = \text{high})}{P(S)} = \dfrac{3}{14} \cdot \dfrac{14}{9} = \underline{\dfrac{1}{3}}$

$P(\text{humidity} = \text{high} \mid S = \text{yes}) = \dfrac{3}{9} = \underline{\dfrac{1}{3}}$ (Table 1: row 2, column 1: 3 times high humidity when soccer was played (9 times total))

$P(\text{temperature} = \text{cold} \mid S = \text{yes}) = \underline{\dfrac{1}{3}}$

$P(\text{forecast} = \text{sunny} \mid S = \text{yes}) = \underline{\dfrac{2}{9}}$

$\Rightarrow P(W|S) = \left(\dfrac{1}{3}\right)^3 \cdot \dfrac{2}{9} = \dfrac{2}{243}$

$P(W = \text{table } 2) = P(\text{wind} = \text{high}) \cdot P(\text{humidity} = \text{low}) \cdot P(\text{temperature} = \text{cold}) \cdot P(\text{forecast} = \text{sunny})$

$= \dfrac{6}{14} \cdot \dfrac{7}{14} \cdot \dfrac{6}{14} \cdot \dfrac{3}{14}$

$= \underline{\dfrac{27}{1372}}$

$\Rightarrow P(S = \text{yes} \mid W = \text{table } 2) = \dfrac{2}{243} \cdot \dfrac{9}{14} \cdot \dfrac{1372}{27} = \underline{\underline{\dfrac{196}{729}}}$

$\approx \underline{\underline{26{,}89\,\%}}$

c)

The problem that occurs is, that there is no data for hot weather when soccer was played. That leads to $P(\text{temperature} = \text{hot} \mid S = \text{yes}) = 0$

$\Rightarrow P(W = \text{table } 3 \mid S = \text{yes}) = 0$ even though the propability should be > 0

To solve that we can calculate $P(S = \text{yes} \mid W) = 1 - P(S = \text{no} \mid W)$

$P(S = \text{no} \mid W) = \dfrac{P(W \mid S = \text{no}) \cdot P(S = \text{no})}{P(W)}$

$P(S = \text{no}) = \underline{\dfrac{5}{14}}$

$P(W \mid S = \text{no}) = \dfrac{2}{5} \cdot \dfrac{4}{5} \cdot \dfrac{1}{5} \cdot \dfrac{1}{5} = \underline{\dfrac{8}{625}}$

$P(W) = \dfrac{8}{14} \cdot \dfrac{7}{14} \cdot \dfrac{1}{14} \cdot \dfrac{3}{14} = \underline{\dfrac{3}{686}}$

$\Rightarrow P(S = \text{yes} \mid W = \text{table } 3) = 1 - \dfrac{8}{625} \cdot \dfrac{5}{14} \cdot \dfrac{686}{3}$

Exercise 17

a) Y: soccer

$$H(Y) = -P(Y=true)\log_2(P(Y=true)) - P(Y=false)\log_2(P(Y=false))$$

$$= -\frac{9}{14}\log_2\left(\frac{9}{14}\right) - \frac{5}{14}\log_2\left(\frac{5}{14}\right)$$

$$\approx 0{,}94$$

b) X: wind

$$H(Y|X) = P(X=true)\cdot H(Y|X=true) + P(X=false)\cdot H(Y|X=false)$$

$$H(Y|X=true) = -\frac{3}{6}\log_2\left(\frac{3}{6}\right) - \frac{3}{6}\log_2\left(\frac{3}{6}\right) = 1$$

$$H(Y|X=false) = -\frac{6}{8}\log_2\left(\frac{6}{8}\right) - \frac{2}{8}\log_2\left(\frac{2}{8}\right) \approx 0{,}811$$

$$\Rightarrow H(Y|X) = \frac{6}{14}\cdot H(Y|X=true) + \frac{8}{14}H(Y|X=false) \approx 0{,}892$$

$$\Rightarrow IG(X,Y) = H(Y) - H(Y|X) = 0{,}94 - 0{,}892 = 0{,}048$$