Maschinelles Lernen 1 - Assignment 2

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1 Exercise

$f =$ a house will be flooded $\neg f =$ a house won't be flooded
$x =$ house stands in a high risk area $\neg x =$ house stands in a low risk area
$P(f) = 0.0005$ $P(\neg f) = 0.9995$
$P(x) = 0.04$ $P(\neg x) = 0.96$
$P(x|f) = 0.8$ $P(\neg x|f) = 0.2$
$\alpha_1 =$ buying insurance $\alpha_2 =$ not buying insurance

We estimate the houses value is 210,000 €, since the text states that 100,000 € is less than half the value.

$\lambda(\alpha_1|f) = 1100€$ $\lambda(\alpha_1|\neg f) = 1100€$
$\lambda(\alpha_2|f) = 110000€$ $\lambda(\alpha_1|\neg f) = 0€$

(a) Bayes Rule:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Compute $P(f|x)$:

$$P(f|x) = \frac{P(x|f)P(f)}{P(x)} = \frac{0.8 \cdot 0.0005}{0.04} = 0.01$$

(b) Compute $R(\alpha_1|x)$ and $R(\alpha_2|x)$:

$$P(\neg f|x) = 1 - P(f|x) = 0.99$$
$$R(\alpha_1|x) = \lambda(\alpha_1|f)P(f|x) + \lambda(\alpha_1|\neg f)P(\neg f|x) = 1100€ * 0.01 + 1100€ * 0.99 = 1100€$$
$$R(\alpha_2|x) = \lambda(\alpha_2|f)P(f|x) + \lambda(\alpha_2|\neg f)P(\neg f|x) = 110000€ * 0.01 + 0€ * 0.99 = 1100€$$

Since $R(\alpha_2|x) = R(\alpha_1|x)$ no option would be more viable than the other.

(c) insert text

2 Exercise

(a) insert text

(b) insert text

3 Exercise

(a)

$$
\begin{aligned}
P(\omega_2|x) &\leq P(\omega_1|x) \\
\Leftrightarrow \quad \frac{P(x|\omega_2)P(\omega_2)}{P(x)} &\leq \frac{P(x|\omega_1)P(\omega_1)}{P(x)} \\
\Leftrightarrow \quad P(x|\omega_2)P(\omega_2) &\leq P(x|\omega_1)P(\omega_1) \\
\Leftrightarrow \quad \frac{1}{\sqrt{2\pi}\sigma} e^{\frac{(x+\mu)^2}{2\sigma^2}} P(\omega_2) &\leq \frac{1}{\sqrt{2\pi}\sigma} e^{\frac{(x-\mu)^2}{2\sigma^2}} P(\omega_1) \\
\Leftrightarrow \quad e^{\frac{(x+\mu)^2}{2\sigma^2}} P(\omega_2) &\leq e^{\frac{(x-\mu)^2}{2\sigma^2}} P(\omega_1) \\
\Leftrightarrow \quad \frac{(x+\mu)^2}{2\sigma^2} + \ln(P(\omega_2)) &\leq \frac{(x-\mu)^2}{2\sigma^2} + \ln(P(\omega_1)) \\
\Leftrightarrow \quad -(x+\mu)^2 + 2\sigma^2 \ln(P(\omega_2)) &\leq -(x-\mu)^2 + 2\sigma^2 \ln(P(\omega_1)) \\
\Leftrightarrow \quad -x^2 - x\mu - \mu^2 + 2\sigma^2 \ln(P(\omega_2)) &\leq -x^2 + x\mu - \mu^2 + 2\sigma^2 \ln(P(\omega_1)) \\
\Leftrightarrow \quad -x^2 - x\mu - \mu^2 + 2\sigma^2 \ln(P(\omega_2)) &\leq -x^2 + x\mu - \mu^2 + 2\sigma^2 \ln(P(\omega_1)) \\
\Leftrightarrow \quad \ln(P(\omega_2)) &\leq \frac{2x\mu}{2\sigma^2} + \ln(P(\omega_1)) \\
\Leftrightarrow \quad P(\omega_2) &\leq e^{\frac{x\mu}{\sigma^2}} P(\omega_1)
\end{aligned}
$$

Therefore:

$$
\int_{x=-\infty}^{\infty} P(error|x)p(x)dx = \int_{x=-\infty}^{\infty} min[P(\omega_1|x); P(\omega_2|x)] = \int_{x=-\infty}^{\infty} P(\omega_2|x)p(x)dx
$$

if $P(\omega_2) \leq e^{\frac{x\mu}{\sigma^2}} P(\omega_1)$.

(b) If we furthermore also assume $\mu_2 = -\mu_1$ for a Laplacian distribution, we need to make a differentiation.

- for $x \geq \mu$, condition for $P(\omega_2)$ does not depend on x any more.
- for $x < \mu$, condition for $P(\omega_2)$ does not depend on μ any more.

4 Exercise