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1. 解: (1) $P(E=F, S=F, M=F, B=F) = P(M=F) \times P(B=F|M=F) \times P(E=F)$
 $\times P(S=F|E=F, M=F)$

则原式 $= 0.9 \times 0.9 \times 0.6 \times 0.9 = 0.4374$

(2) 即求 $P(B=T) = P(B=T|M=T) \times P(M=T) + P(B=T|M=F) \times P(M=F)$

则原式 $= 1.0 \times 0.1 + 0.1 \times 0.9 = 0.19$

(3) 由题 $P(M=T|B=T) = \frac{P(B=T|M=T) \times P(M=T)}{P(B=T)}$

代入: $\frac{1.0 \times 0.1}{0.19} = 0.5263$

(4) 由题 $P(M=T|S=T, B=T, E=T)$

$= \frac{P(S=T|E=T, M=T) \times P(E=T) \times P(M=T) \times P(B=T|M=T)}{\sum_{m \in \{T, F\}} P(S=T|E=T, m) \times P(E=T) \times P(m) \times P(B=T|m)}$

代入: $\frac{1.0 \times P(E=T) \times 0.1 \times 1.0}{P(E=T) \times (1.0 \times 0.1 \times 1.0 + 0.8 \times 0.9 \times 0.1)}$

$= \frac{0.1}{0.1 + 0.072} = 0.5814$

(5) $P(E=T|M=T)$ 由题图两事件相互独立

$P(E=T|M=T) = P(B=T) = 0.4$

2. 信息熵 $H(D) = -\frac{3}{5} \log_2 \frac{3}{5} - \frac{2}{5} \log_2 \frac{2}{5} \approx 0.97$

① $Gain(天气) = H(D) - \frac{2}{5} H(D|晴) - \frac{1}{5} H(D|阴) - \frac{2}{5} H(D|雨)$

$= H(D) - \frac{2}{5} (-\frac{2}{5} \log_2 \frac{2}{5}) - \frac{1}{5} (-\frac{1}{5} \log_2 \frac{1}{5}) - \frac{2}{5} (-\frac{2}{5} \log_2 \frac{2}{5})$

$= 0.97 - 0 = 0.97$

② $Gain(湿度) = H(D) - \frac{3}{5} H(D|高) - \frac{2}{5} H(D|中)$

$= H(D) - \frac{3}{5} (-\frac{2}{5} \log_2 \frac{2}{5} - \frac{1}{5} \log_2 \frac{1}{5}) - \frac{2}{5} (-\frac{2}{5} \log_2 \frac{2}{5})$

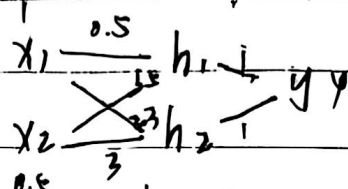
$= H(D) - 0.55 - 0$

$= 0.42$

综上 $Gain(天气) > Gain(湿度)$, 故天气更适合作根。

3.1

前向传播 $h_{1in} = w_1 x_1 + w_2 x_2 = 0.5 \times 1 + 1.5 \times 0.5$
 $= 1.2570$



$h_{2in} = w_3 x_1 + w_4 x_2 = 2.3 \times 1 + 3 \times 0.5$
 $= 3.870$

$h_1 = 1.25$

$h_2 = 3.8$

$y_{in} = w_5 h_1 + w_6 h_2 = 1.25 + 3.8 = 5.0570$ $y = 5.05$

误差 (MSE): $L = \frac{1}{2} (y - t)^2 = 0.55125$

$\frac{\partial L}{\partial y} = (y - t)$ $\delta_y = \frac{\partial L}{\partial y} \cdot \frac{\partial y}{\partial y_{in}} = (y - t) = 1.05$

$\delta h_1 = \frac{\partial L}{\partial h_{1in}} = \frac{\partial L}{\partial y} \cdot \frac{\partial y}{\partial y_{in}} \cdot \frac{\partial y_{in}}{\partial h_{1in}} = \delta_y w_5 (ReLu)' = 1.05$

同理 $\delta h_2 = 1.05$

梯度下降更新 $W^+ = W - \eta \frac{\partial L}{\partial W}$ $\eta = 0.1$

$\frac{\partial L}{\partial w_5} = \frac{\partial L}{\partial y_{in}} \cdot \frac{\partial y_{in}}{\partial w_5} = \delta_y \cdot h_1 = 0.13125$

$\frac{\partial L}{\partial w_1} = \frac{\partial L}{\partial h_{1in}} \cdot \frac{\partial h_{1in}}{\partial w_1} = \delta h_1 \cdot x_1 = 1.05$

则 $w_5^+ = w_5 - 0.1 \times 0.13125 = 0.86875$

$w_1^+ = w_1 - 0.1 \times 1.05 = 0.395$

4.47

核1: $C1W1 = \begin{bmatrix} 1 & 2 & 3 & 0 \\ 2 & 4 & 3 & 3 \\ 3 & 3 & 5 & 1 \\ 0 & 3 & 1 & 2 \end{bmatrix}$

$C2W2 = \begin{bmatrix} 0 & 3 & 2 & 1 \\ 3 & 4 & 2 & 3 \\ 2 & 2 & 6 & 2 \\ 1 & 3 & 2 & 0 \end{bmatrix}$ bias=1

则 $\begin{bmatrix} 2 & 6 & 6 & 2 \\ 6 & 9 & 6 & 7 \\ 6 & 6 & 12 & 4 \\ 2 & 7 & 4 & 3 \end{bmatrix}$

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$$\text{核2 } C_1 W_1: \begin{bmatrix} -1 & -2 & -3 & 0 \\ -2 & -2 & 1 & 3 \\ -3 & 1 & 1 & 1 \\ 0 & 3 & 1 & 2 \end{bmatrix} \quad C_2 W_2: \begin{bmatrix} 0 & -3 & -2 & -1 \\ 3 & 0 & 0 & -3 \\ 2 & 0 & 0 & -2 \\ 1 & 3 & 2 & 0 \end{bmatrix} \quad \text{bias} = 2$$

$$m] \begin{bmatrix} 1 & -3 & -3 & 1 \\ 3 & 0 & 3 & 2 \\ 1 & 3 & 3 & 1 \\ 3 & 8 & 5 & 4 \end{bmatrix}$$

$$\text{维度公式: } h = \left\lfloor \frac{n_h - f + 2p}{s} \right\rfloor + 1 = 4$$

$$w = \left\lfloor \frac{m_w - f + 2p}{s} \right\rfloor + 1 = 4$$

4x4 符合结果

(2) 平均池化:

$$\text{核1} \begin{bmatrix} 5.75 & 5.25 \\ 5.25 & 5.75 \end{bmatrix} \quad \text{核2} \begin{bmatrix} 0.25 & 0.75 \\ 3.75 & 3.25 \end{bmatrix}$$

最大池化:

$$\text{核1} \begin{bmatrix} 9 & 7 \\ 7 & 12 \end{bmatrix} \quad \text{核2} \begin{bmatrix} 3 & 3 \\ 8 & 5 \end{bmatrix}$$