

Named Tensors: CNN / LeNet

Conv 2D

$$\begin{aligned}
 W &\in \mathbb{R}^{\text{channel}:c, \text{kh}:kh, \text{kw}:kw} \\
 h' &= h - kh + 1, w' = w - kw + 1 \\
 b &\in \mathbb{R}^{\text{height}:h', \text{width}:w'} \\
 \text{conv2d}(X; W, b) &= W \underset{\text{channel}, \text{kh}, \text{kw}}{\cdot} U + b \\
 U &\in \mathbb{R}^{\text{channel}:c, \text{height}:h', \text{width}:w', \text{kh}:kh, \text{kw}:kw} \\
 U_{\text{height}:i, \text{width}:j, \text{kh}:i', \text{kw}:j'} &= X_{\text{height}:i+i'-1, \text{width}:j+j'-1}
 \end{aligned}$$

Max Pooling

$$\begin{aligned}
 X &\in \mathbb{R}^{\text{height}:h, \text{width}:w} \\
 \text{maxpool2d}(X, kh, kw) &= \max_{\text{kh}, \text{kw}} U \\
 U &\in \mathbb{R}^{\text{height}:h/kh, \text{width}:w/kw, \text{kh}:kh, \text{kw}:kw} \\
 U_{\text{height}:i, \text{width}:j, \text{kh}:di, \text{kw}:dj} &= X_{\text{height}:i \times kh + di - 1, \text{width}:j \times kw + dj - 1}
 \end{aligned}$$

MLP

$$\begin{aligned}
 W^1 &\in \mathbb{R}^{\text{inp}:i, \text{hidden}:h}, W^2 \in \mathbb{R}^{\text{hidden}:h} \\
 \text{MLP}(X; W, b) &= W^1_{\text{hidden}} \cdot \text{ReLU}(W^1_{\text{inp}} \cdot X + b^1) + b^2
 \end{aligned}$$

Model

Params :

$$W^1 \in \mathbb{R}^{\text{channels}':c_2, \text{channels}:c_1, \text{kh}:kh_1, \text{kw}:kw_1}$$

$$W^2 \in \mathbb{R}^{\text{channels}':c_3, \text{channels}:c_2, \text{kh}:kh_2, \text{kw}:kw_2}$$

$$U \in \mathbb{R}^{\text{in}:h_1, \text{hidden}:h_2}, V \in \mathbb{R}^{\text{hidden}:h_2, \text{out}:h_3}$$

Model :

$$X^0 \in \mathbb{R}^{\text{batch}:b, \text{channels}:1, \text{height}:h, \text{width}:w}$$

$$X^1 = [\text{ReLU}(\text{conv2d}(X^0; W^1))]_{\text{channels}' \rightarrow \text{channels}}$$

$$X^2 = \text{maxpool2d}(X^1, ph_1, ph_2)$$

$$X^3 = [\text{ReLU}(\text{conv2d}(X^2; W^2))]_{\text{channels}' \rightarrow \text{channels}}$$

$$X^4 = \text{maxpool2d}(X^3, ph_2, ph_2)$$

$$X^5 \in \mathbb{R}^{\text{batch}:b, \text{inp}:h_1}$$

$$X_{\text{inp}}^5 = X_{\text{height}, \text{width}, \text{channels}}^4$$

$$O = \underset{\text{class}}{\text{softmax}} [\text{MLP}(X^5; U, V)]_{\text{out} \rightarrow \text{class}}$$