

卷积和池化反向传播

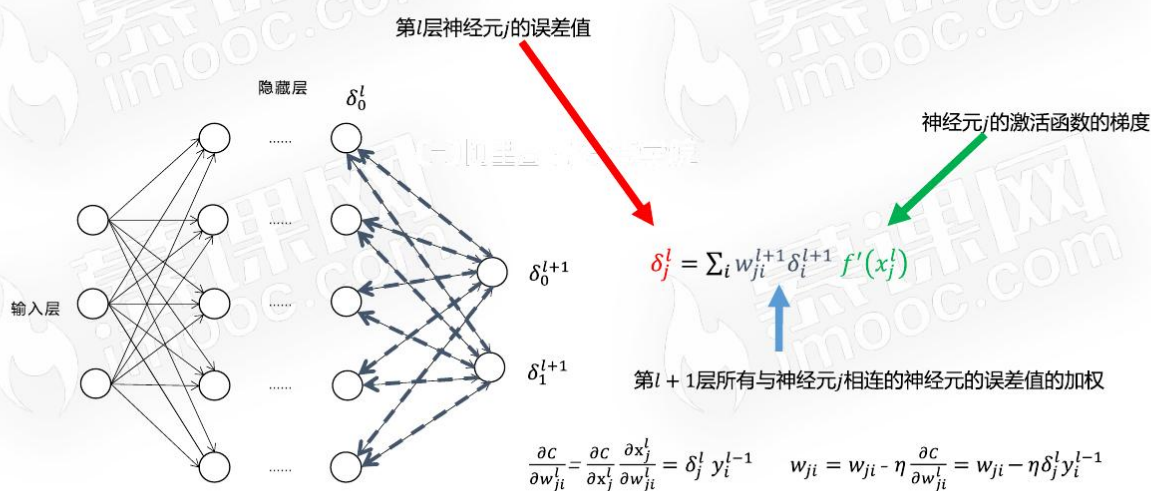
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卷积操作反向传播

误差反向传播算法

◆ 反向传播算法求解



卷积误差反向传播

◆ 多通道卷积的误差反向传播

第l层输出为 $z^{(l,d)}$ ，d表示通道数

第l层输入为 $x^{(l,d)}$ ，表示通道索引

卷积核为 $w^{(l+1,p,d)}$ ，表示有边界填充的卷积操作

当前节点的误差，等于下一层所有与该节点相连的误差与卷积核旋转180度后进行卷积，再与当前层的梯度相乘

$$\delta^{(l,d)} = \frac{\partial L}{\partial z^{(l,d)}} = \frac{\partial x^{(l,d)}}{\partial z^{(l,d)}} \frac{\partial L}{\partial x^{(l,d)}} = \frac{\partial x^{(l,d)}}{\partial z^{(l,d)}} \sum_{p=1}^P \frac{\partial z^{(l+1,p)}}{\partial x^{(l,d)}} \otimes \frac{\partial L}{\partial z^{(l+1,p)}} = f'(z^{(l,d)}) (\sum_{p=1}^P \frac{\partial z^{(l+1,p)}}{\partial x^{(l,d)}} \otimes \delta^{(l+1,p)}) = f'(z^{(l,d)}) \odot \sum_{p=1}^P (rot180(w^{(l+1,p,d)}) \otimes \delta^{(l+1,p)})$$

卷积误差反向传播案例

◆ 案例

$$\begin{pmatrix} w_{11} & w_{12} \\ w_{21} & w_{22} \end{pmatrix} \otimes \begin{pmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{pmatrix} = \begin{pmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{pmatrix}$$

$$\frac{z}{\partial x_{11}} = w_{11}$$

$$\frac{z}{\partial x_{12}} = w_{11} + w_{12}$$

$$\frac{z}{\partial x_{13}} = w_{12}$$

$$\frac{z}{\partial x_{21}} = w_{11} + w_{21}$$

$$\frac{z}{\partial x_{22}} = w_{11} + w_{12} + w_{21} + w_{22}$$

$$\frac{z}{\partial x_{23}} = w_{12} + w_{22}$$

$$\frac{z}{\partial x_{31}} = w_{21}$$

$$\frac{z}{\partial x_{32}} = w_{21} + w_{22}$$

$$\frac{z}{\partial x_{33}} = w_{22}$$

$$z_{11} = x_{11}w_{11} + x_{12}w_{12} + x_{21}w_{21} + x_{22}w_{22}$$

$$z_{12} = x_{12}w_{11} + x_{13}w_{12} + x_{22}w_{21} + x_{23}w_{22}$$

$$z_{21} = x_{21}w_{11} + x_{22}w_{12} + x_{31}w_{21} + x_{32}w_{22}$$

$$z_{22} = x_{22}w_{11} + x_{23}w_{12} + x_{32}w_{21} + x_{33}w_{22}$$

$$\frac{\partial z^{(l+1,p)}}{\partial x^{(l,d)}} = (rot180(w^{(l+1,p,d)}) \otimes I)$$

$$\begin{pmatrix} w_{11} & w_{11}+w_{12} & w_{12} & w_{12} \\ w_{11}+w_{21} & w_{11}+w_{12}+w_{21}+w_{22} & w_{12}+w_{22} & w_{12}+w_{22} \\ w_{21} & w_{21}+w_{22} & w_{22} & w_{22} \end{pmatrix} = \begin{pmatrix} w_{22} & w_{21} \\ w_{12} & w_{11} \end{pmatrix} \otimes \begin{pmatrix} 0,0,0,0 \\ 0,1,1,0 \\ 0,1,1,0 \\ 0,0,0,0 \end{pmatrix}$$

池化操作反向传播

池化误差反向传播

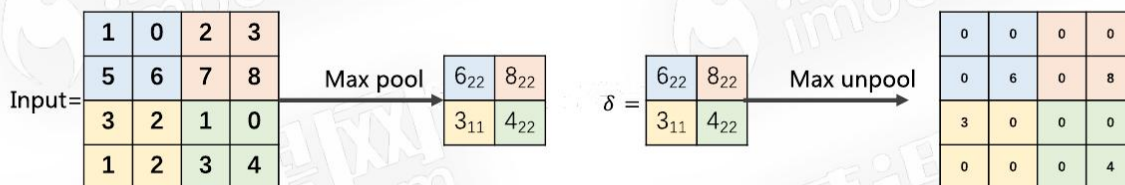
◆ 池化的误差反向传播

(\quad) (\quad) (\quad)

是上采样函数

池化误差反向传播案例

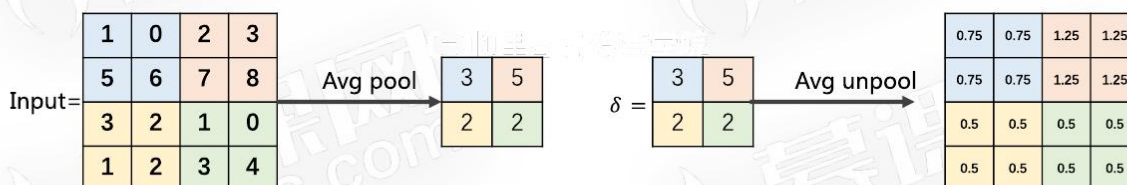
◆ 最大池化的误差反向传播



记录下最大池化的位置，然后进行上采样填充

池化误差反向传播案例

◆ 平均池化的误差反向传播



误差均匀分布到每个位置

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