

$$\begin{aligned}
&= \iint f(z)g(x-z) e^{-i\xi x} dx dz \\
x-z=y &= \iint f(z)g(y) e^{-i\xi(z+y)} dy dz \\
x=z+y & \\
dx=dy &= \iint f(z) e^{-i\xi z} g(y) e^{-i\xi y} dy dz \\
&= \int f(z) e^{-i\xi z} dz \int g(y) e^{-i\xi y} dy \\
&= \hat{f}(\xi) \hat{g}(\xi)
\end{aligned}$$

$$\boxed{
\begin{aligned}
u(x) &= (f * g)(x) \\
\Rightarrow \hat{u}(\xi) &= \hat{f}(\xi) \hat{g}(\xi)
\end{aligned}
}$$

$$\Rightarrow \begin{matrix} V_{21} \\ V_{22} \\ \vdots \\ V_{2d_1} \end{matrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} g_{21} \\ g_{22} \end{bmatrix} 2 \times 1$$

$$\begin{cases} u_{21} = g_{21} V_{21} + g_{22} V_{22} \\ u_{22} = g_{21} V_{22} + g_{22} V_{23} \\ \vdots \\ u_{25} = g_{21} V_{25} + g_{22} V_{26} \end{cases}$$

$$\begin{bmatrix} u_{14} + u_{24} + b_1 \\ u_{15} + u_{25} + b_1 \end{bmatrix}$$

feature map

$$\Rightarrow \begin{matrix} V_{11} \\ V_{12} \\ \vdots \\ V_{1d_1} \end{matrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} g_{11}^{(2)} \\ g_{12}^{(2)} \end{bmatrix}$$

$$\begin{cases} u_{11} = g_{11}^{(2)} V_{11} + g_{12}^{(2)} V_{12} \\ u_{12} = g_{11}^{(2)} V_{12} + g_{12}^{(2)} V_{13} \\ \vdots \\ u_{15} = g_{11}^{(2)} V_{15} + g_{12}^{(2)} V_{16} \end{cases}$$

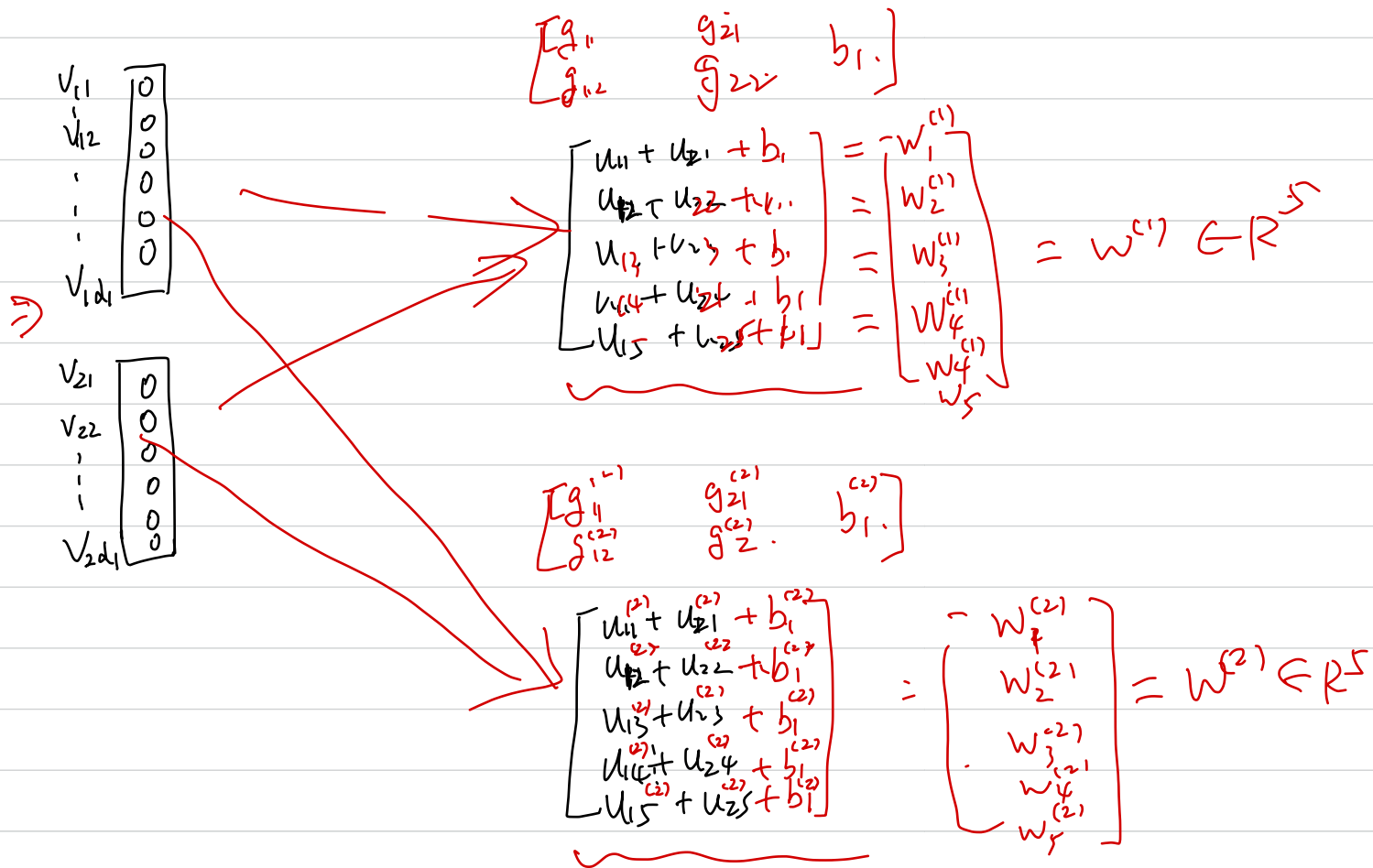
$$\begin{bmatrix} g_{11}^{(2)} & g_{21}^{(2)} & b_1^{(2)} \\ g_{12}^{(2)} & g_{22}^{(2)} & b_1^{(2)} \end{bmatrix}$$

$$\Rightarrow \begin{matrix} V_{21} \\ V_{22} \\ \vdots \\ V_{2d_1} \end{matrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} g_{21}^{(2)} \\ g_{22}^{(2)} \end{bmatrix}$$

$$\begin{cases} u_{21} = g_{21}^{(2)} V_{21} + g_{22}^{(2)} V_{22} \\ u_{22} = g_{21}^{(2)} V_{22} + g_{22}^{(2)} V_{23} \\ \vdots \\ u_{25} = g_{21}^{(2)} V_{25} + g_{22}^{(2)} V_{26} \end{cases} +$$

$$\begin{bmatrix} u_{11}^{(2)} + u_{21}^{(2)} + b_1^{(2)} \\ u_{12}^{(2)} + u_{22}^{(2)} + b_1^{(2)} \\ u_{13}^{(2)} + u_{23}^{(2)} + b_1^{(2)} \\ u_{14}^{(2)} + u_{24}^{(2)} + b_1^{(2)} \\ u_{15}^{(2)} + u_{25}^{(2)} + b_1^{(2)} \end{bmatrix}$$

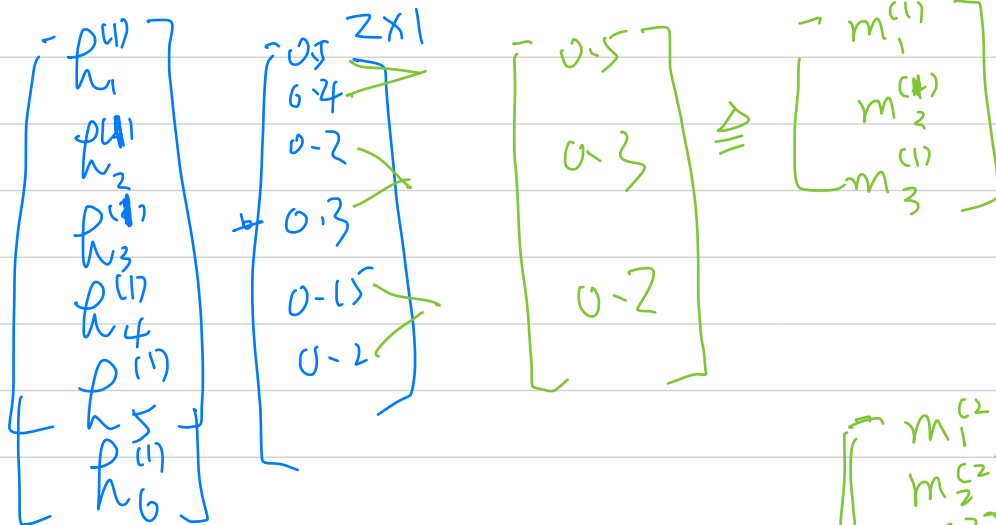


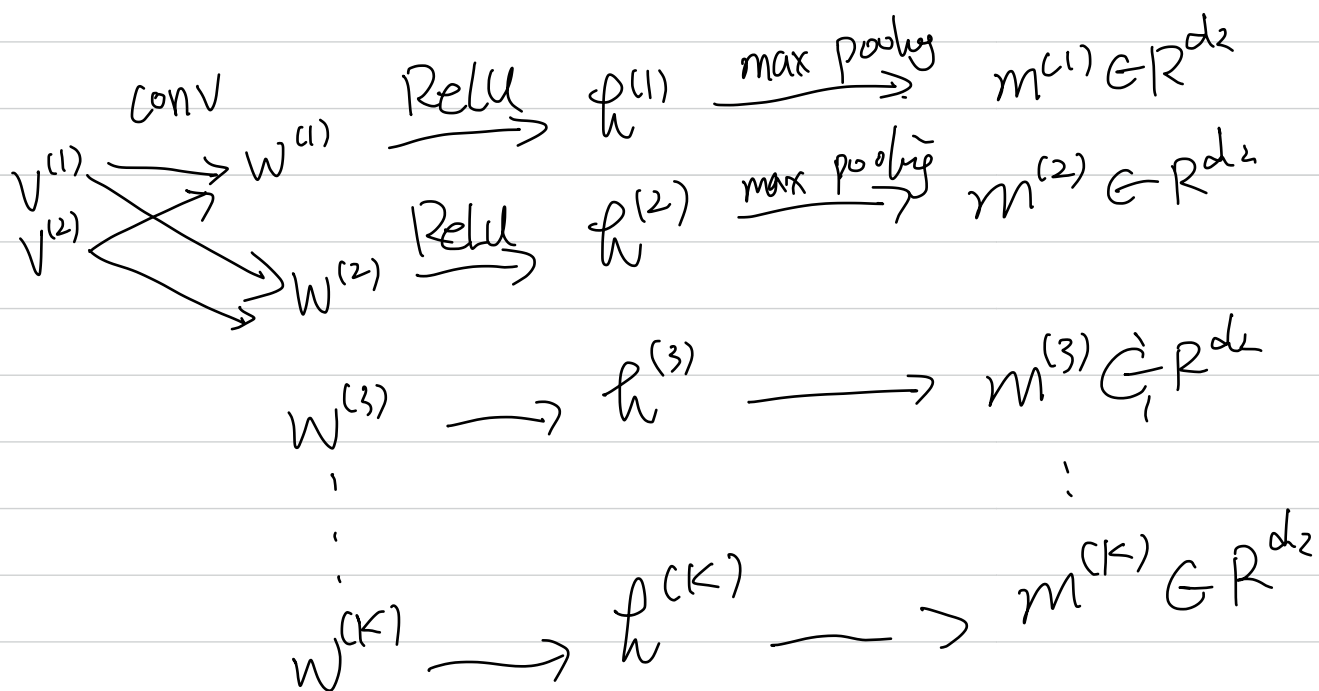
ReLU

$$h^{(1)} = \text{ReLU}(W^{(1)})$$

$$h^{(2)} = \text{ReLU}(W^{(2)})$$

max pooling

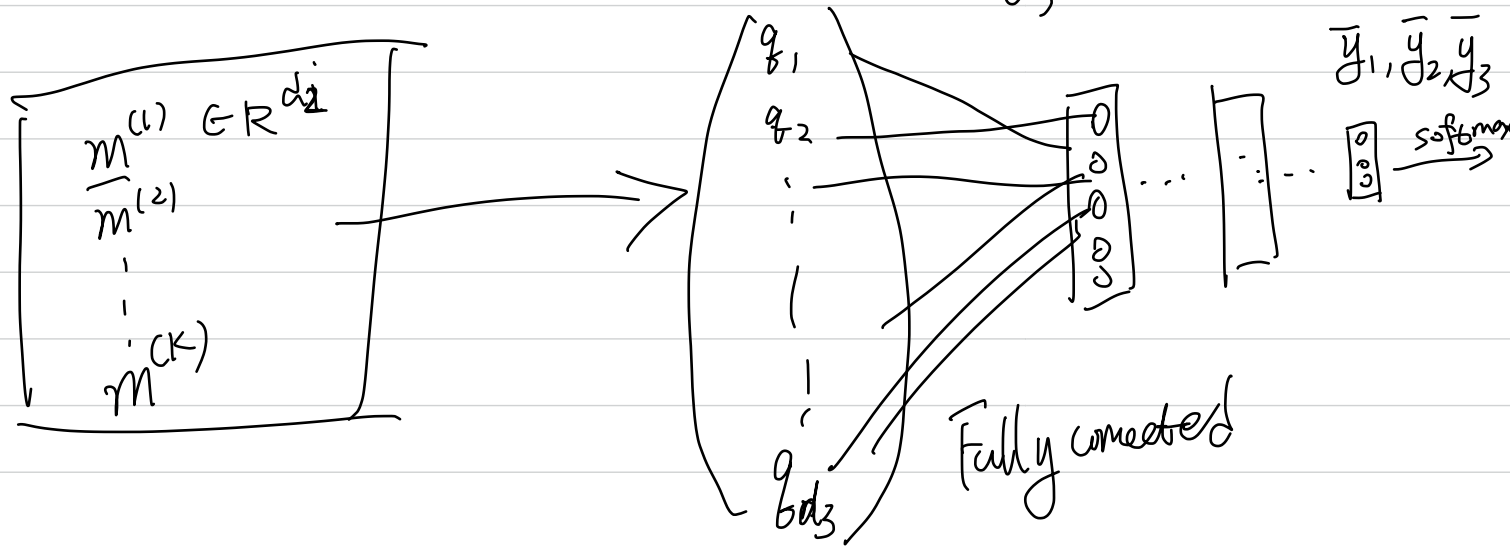




$$\begin{aligned} \frac{1}{2} \quad V^{(1)} &\leftarrow m^{(1)} \\ V^{(2)} &\leftarrow m^{(2)} \\ V^{(K)} &\leftarrow m^{(K)} \end{aligned}$$

重复上述计算过程

$d_3 = k \cdot d_2$



$$\begin{array}{l}
 y_1 \\
 y_2 \\
 y_3
 \end{array}
 \xrightarrow{\text{Softmax}}
 \begin{array}{l}
 \frac{\exp(\bar{y}_1)}{\sum_{i=1}^3 \exp(\bar{y}_i)} \hat{=} \hat{y}_1 \\
 \frac{\exp(\bar{y}_2)}{\sum \exp(\bar{y}_i)} \hat{=} \hat{y}_2 \\
 \frac{\exp(\bar{y}_3)}{\sum \exp(\bar{y}_i)} \hat{=} \hat{y}_3
 \end{array}$$

$$\begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix}$$

$$\begin{pmatrix} \hat{y}_1 \\ \hat{y}_2 \\ \hat{y}_3 \end{pmatrix}$$

$$\begin{array}{l}
 y_i = 1 \quad \hat{y}_i = 1 \Rightarrow L = 0 \\
 y_i = 0 \quad \hat{y}_i < 1 \Rightarrow L > 0
 \end{array}$$

$$\text{Loss} = - \left\{ \begin{array}{l}
 y_1 \log(\hat{y}_1) + (1 - y_1) \log(1 - \hat{y}_1) \\
 + y_2 \log \hat{y}_2 + (1 - y_2) \log(1 - \hat{y}_2) \\
 + y_3 \log \hat{y}_3 + (1 - y_3) \log(1 - \hat{y}_3) \end{array} \right\}$$

$$\hat{y}_i^+ = \hat{y}_i^- - y \frac{\partial \text{Loss}}{\partial \hat{y}_i}$$

MNIST

784

28x28

32 conv 3x3.

$$9 \times 32 + 32$$

26x26 pooling

13x13 32

64 conv 3x3

$$64 \times (9 \times 32 + 1)$$

24x24 x 64

400

$$400 + 24 \times 24 \times 64 \times 400 = m_2$$

10

$$400 \times 10 + 10$$