$$= \iint f(z)\, g(x-z)\, e^{-i\xi x}\, dx\, dz$$

$x - z = y$

$$= \iint f(z)\, g(y)\, e^{-i\xi(z+y)}\, dy\, dz$$

$x = z + y$

$dx = dy$

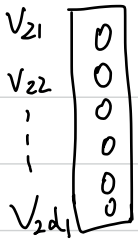
$$= \iint f(z)\, e^{-i\xi z}\, g(y)\, e^{-i\xi y}\, dy\, dz$$

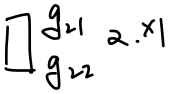
$$= \int f(z)\, e^{-i\xi z}\, dz \int g(y)\, e^{-i\xi y}\, dy$$

$$= \hat{f}(\xi)\, \hat{g}(\xi)$$

$$u(x) = (f * g)(x)$$

$$\Rightarrow \hat{u}(\xi) = \hat{f}(\xi)\, \hat{g}(\xi)$$

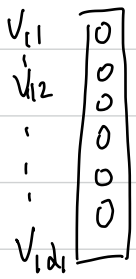




$$\begin{bmatrix} u_{21} = g_{21}V_{21} + g_{22}V_{22} \\ u_{22} = g_{21}V_{22} + g_{22}V_{23} \\ \vdots \\ u_{25} = g_{21}V_{25} + g_{22}V_{26} \end{bmatrix}$$

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

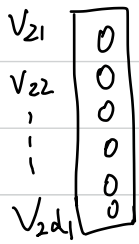
feature map

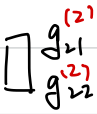


$$\begin{bmatrix} u_{11}^{(2)} = g_{11}^{(2)}V_{11} + g_{12}^{(2)}V_{12} \\ u_{12}^{(2)} = g_{11}^{(2)}V_{12} + g_{12}^{(2)}V_{13} \\ \vdots \\ u_{15}^{(2)} = g_{11}^{(2)}V_{15} + g_{12}^{(2)}V_{16} \end{bmatrix}$$

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

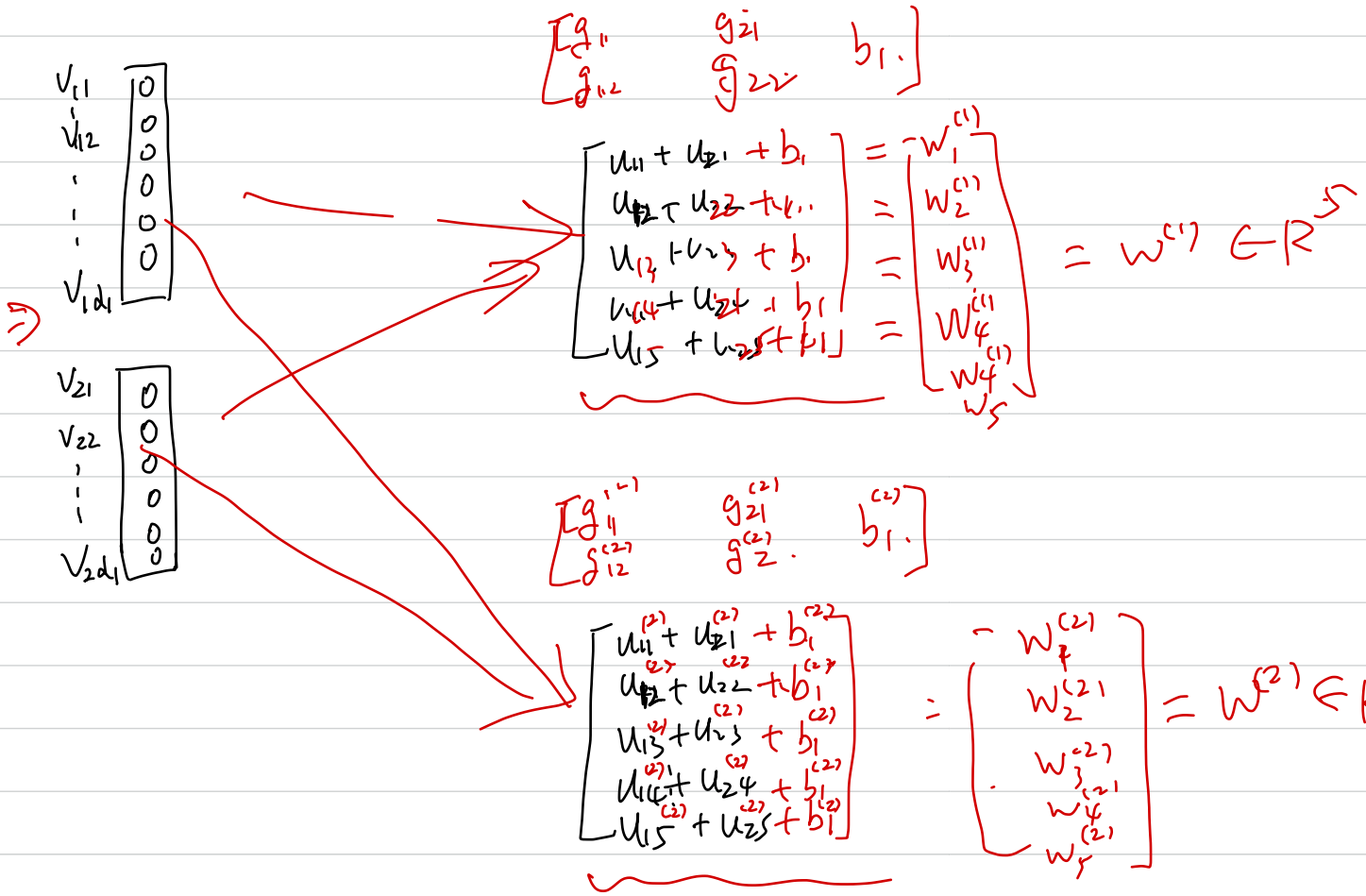
$$\begin{bmatrix} u_{11}^{(2)} + u_{21}^{(2)} + b_1^{(2)} \\ u_{12}^{(2)} + u_{22}^{(2)} + b_1^{(2)} \\ u_{13}^{(2)} + u_{23}^{(2)} + b_1^{(2)} \\ u_{14}^{(2)} + u_{24}^{(2)} + b_1^{(2)} \\ u_{15}^{(2)} + u_{25}^{(2)} + b_1^{(2)} \end{bmatrix}$$





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

+

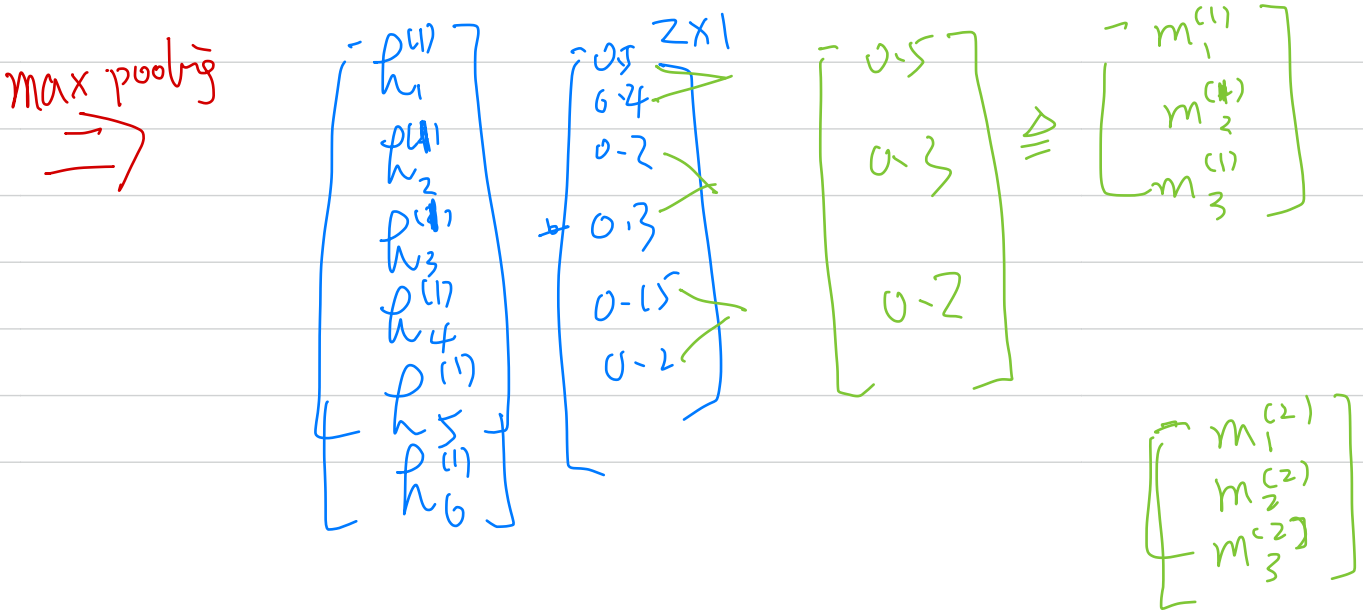


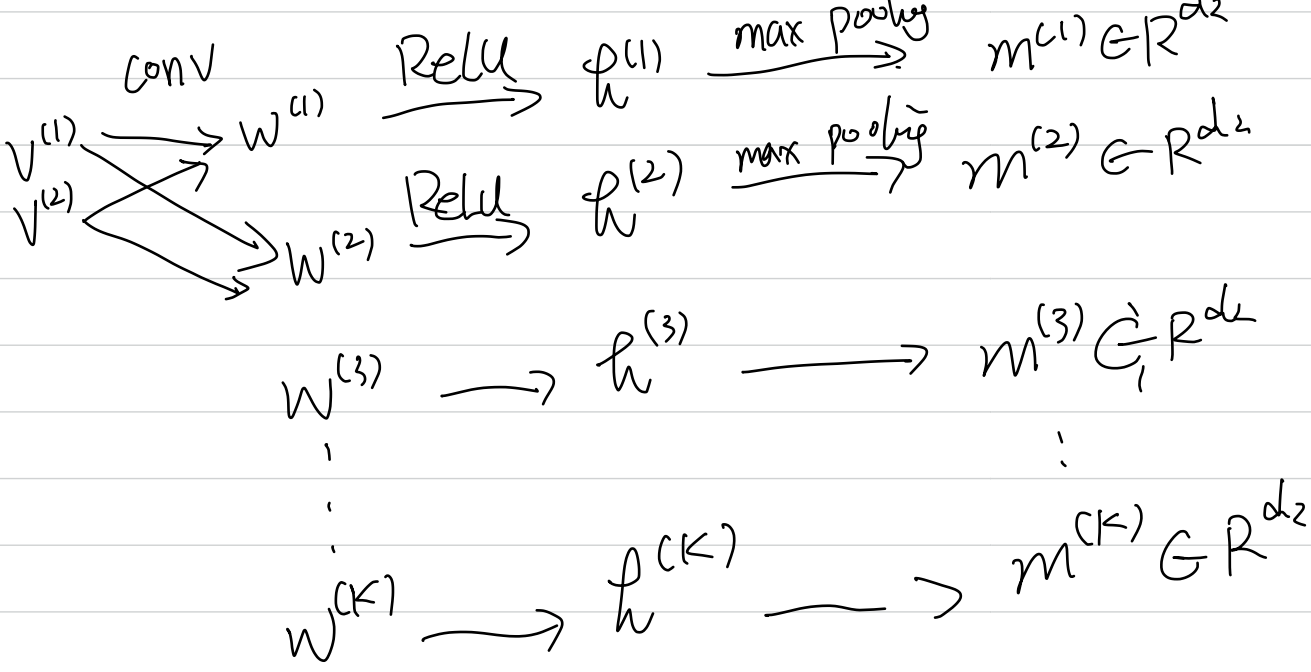
ReLU

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

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

max pooling





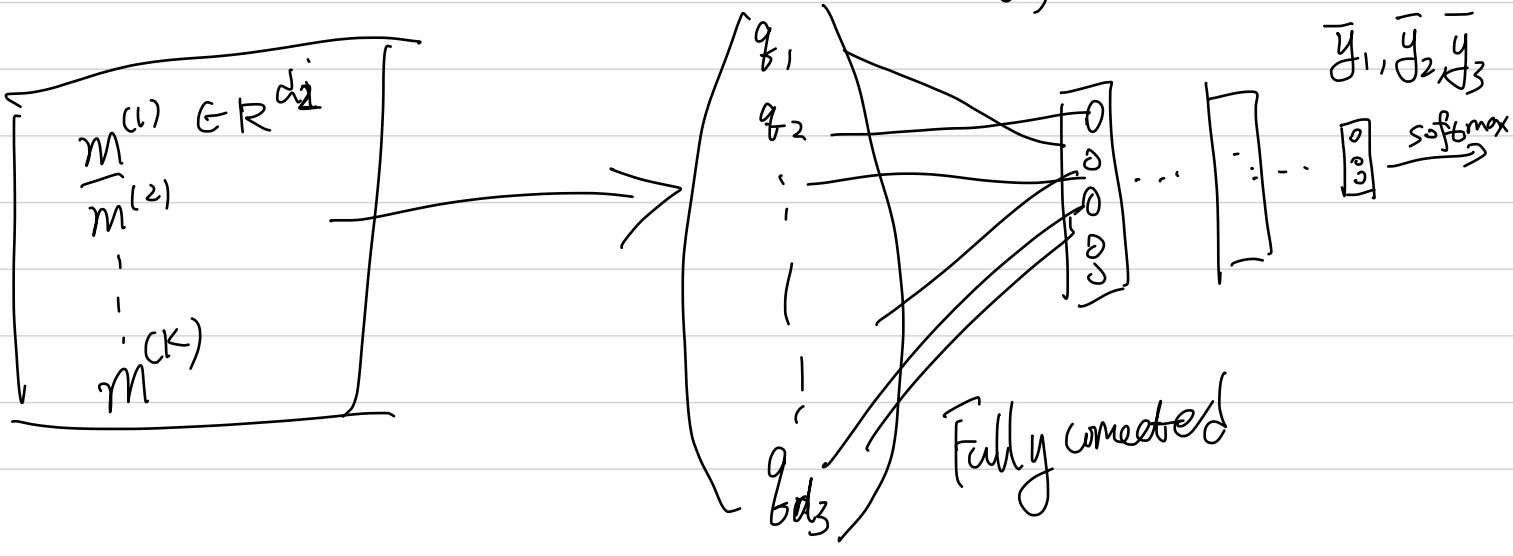
$v^{(1)} \leftarrow m^{(1)}$

$v^{(2)} \leftarrow m^{(2)}$

$v^{(K)} \leftarrow m^{(K)}$

重复上述计算过程

$d_3 = K \cdot d_2$.



$$\bar{y}_1, \bar{y}_2, \bar{y}_3 \xrightarrow{\text{Softmax}}$$

$$\frac{\exp(\bar{y}_1)}{\sum_{i=1}^{3}\exp(\bar{y}_i)} \triangleq \hat{y}_1$$

$$\frac{\exp(\bar{y}_2)}{\sum \exp(\bar{y}_i)} \triangleq \hat{y}_2$$

$$\frac{\exp(\bar{y}_3)}{\sum \exp(\bar{y}_i)} \triangleq \hat{y}_3$$

$$\begin{pmatrix} \hat{y}_1 \\ \hat{y}_2 \\ \hat{y}_3 \end{pmatrix} \qquad \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix}$$

※ $y_i=1 \quad \hat{y}_i=1 \Rightarrow L=0$

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

$$\text{Loss} = -\{ y_1 \log(\hat{y}_1) + (1-y_1)\log(1-\hat{y}_1) + y_2 \log \hat{y}_2 + (1-y_2)\log(1-\hat{y}_2) + y_3 \log \hat{y}_3 + (1-y_3)\log(1-\hat{y}_3) \}$$

$$g_i^+ = g_i^- - \gamma \frac{\partial \text{Loss}}{\partial g_i}$$

MNIST 784 28x28:

32 conv 3x3.

$9 \times 32 + 32$

26x26 pooling

13x13 32

64 conv 3x3

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

24x24 x64

400

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

10

$400 \times 10 + 10$