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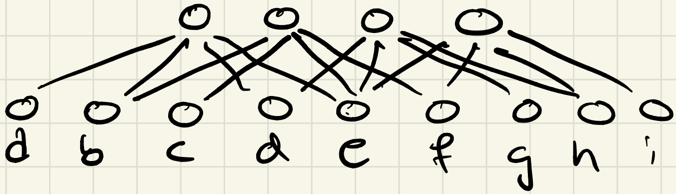
Exercise 9

1.



$$W = \begin{bmatrix} w_{11} & w_{12} & 0 & w_{21} & w_{22} & 0 & 0 & 0 & 0 \\ 0 & w_{11} & w_{12} & 0 & w_{21} & w_{22} & 0 & 0 & 0 \\ 0 & 0 & 0 & w_{11} & w_{12} & 0 & w_{21} & w_{22} & 0 \\ 0 & 0 & 0 & 0 & w_{11} & w_{12} & 0 & w_{21} & w_{22} \end{bmatrix}$$

Columns: [a, b, c, d, e, f, g, h, i] Rows: 4 output neurons

2.

$$f(x,y) := I_{x,y} \qquad g(p,q) := \begin{cases} w_{1-p,1-q}, & 1-M \leq p,q \leq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$(f * g)(i,j) = \sum_x \sum_y I_{x,y}\, g(i-x, j-y)$$

$$= \sum_x \sum_y I_{x,y}\, w_{1-(i-x),1-(i-y)}$$

$$= \sum_x \sum_y I_{x,y}\, w_{x-i+1,y-j+1}$$

Since $w_{m,n}$ is non-zero only for $m,n \in \{1,\dots,M\}$, this reduces to

$$(f*g)(i,j) = \sum_{m=1}^{M} \sum_{n=1}^{M} I_{i+m-1,j+n-1}\, w_{m,n} = z_{in,i,j}$$

So with $f = I$ and g defined above, we have $z_{in,i,j} = h(i,j) = (f*g)(i,j)$

3.

$h_1 = 2 + 0 + 2 + 0 = 4$

$h_2 = 3 + 1 + 3 + 1 = 8$

$h_3 = 0 + 1 + 0 + 1 = 2$

$h_4 = 1 + 1 + 1 + 1 = 4$

Calculated by using dot product.

final outputs are $(4 + 8 + 2 + 4)$.