Number of weights (N_w) = 7

Example for f having 9 pixels $(x_0, x_1, ...x_8)$:

$$\text{Convolution matrix} = \underbrace{\begin{bmatrix} w_3 & w_4 & w_5 & w_6 & 0 & 0 & 0 & 0 & 0 \\ w_2 & w_3 & w_4 & w_5 & w_6 & 0 & 0 & 0 & 0 \\ w_1 & w_2 & w_3 & w_4 & w_5 & w_6 & 0 & 0 & 0 \\ w_0 & w_1 & w_2 & w_3 & w_4 & w_5 & w_6 & 0 & 0 \\ 0 & w_0 & w_1 & w_2 & w_3 & w_4 & w_5 & w_6 & 0 \\ 0 & 0 & w_0 & w_1 & w_2 & w_3 & w_4 & w_5 & w_6 \\ 0 & 0 & 0 & w_0 & w_1 & w_2 & w_3 & w_4 & w_5 \\ 0 & 0 & 0 & 0 & w_0 & w_1 & w_2 & w_3 & w_4 \\ 0 & 0 & 0 & 0 & 0 & w_0 & w_1 & w_2 & w_3 \end{bmatrix}}_{W \in \mathbb{R}^{9\times 9}} \underbrace{\begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \\ x_8 \end{bmatrix}}_{\mathbf{f} \in \mathbb{R}^9} \tag{1}$$

Properties:

W is a sparse square matrix and its inverse can be easily computed.

Application:

W is a square matrix, and one could apply binary exponentiation to calculate the n^{th} convolution very quickly.