# Problem 1

April 13, 2024

## Convolution with stride of 1

To initiate the operation, align the filter to the topmost left position against the input matrix and compute the dot product of the overlapping elements. The first element of the result matrix will capture this initial value. Proceed by horizontally sliding the filter step by step to the right until reaching the matrix's boundary. Following this, move the filter down one level to start the next horizontal sequence, continuing in this manner to fill the result matrix.

$$\begin{bmatrix} 1 & 6 & 4 \\ 0 & 3 & 3 \\ -5 & 1 & 5 \end{bmatrix}$$

## Zero padding of 1 + convolution with stride of 1

To perform convolution with a stride of 1 on a matrix with zero padding, start by adding a border of zeros around the original input matrix. The process continues as before, computing dot products after aligning the filter with the top-left corner of the zero-padded input matrix, then sliding the filter right and down to populate the output matrix.

$$\begin{bmatrix} -3 & -2 & 2 & 1 & 1 \\ -7 & -1 & 0 & 1 & 1 \\ 5 & 0 & 3 & 3 & 2 \\ -5 & -5 & 1 & 5 & 4 \\ -1 & -6 & -3 & 5 & 4 \end{bmatrix}$$

## Zero padding of 2 + convolution with stride of 2

To perform convolution with a stride of 2 on a matrix with zero padding, first pad the input matrix with a border of zeros that is two units wide on all sides. Then, apply the filter across the padded matrix with a stride of 2, meaning that the filter will jump two rows and two columns on each step.

$$\begin{bmatrix} 0 & -4 & 4 & 0 \\ -5 & -1 & 4 & 2 \\ -4 & -5 & 5 & 4 \\ 0 & -3 & 2 & 1 \end{bmatrix}$$

## Convolution with stride of 1 + max pooling of 3 with stride of 1

. Apply the 3x3 filter to the input matrix for convolution with stride 1, generating a new feature map. Then, perform max pooling with a 3x3 window and stride 1 on this feature map, extracting the maximum value from each window to form the pooled output matrix.

$$\begin{bmatrix} 0 \end{bmatrix}$$

Apply a two-layer zero padding to the input matrix, then convolve with a stride of 1 using the given filter. Lastly, downsample the convolved output by applying max pooling with a 3x3 window and stride of 1, selecting the maximum value within each window for the final output matrix.

$$\begin{bmatrix} 0 & 6 & 6 & 6 & 4 \\ 0 & 6 & 6 & 6 & 4 \\ 0 & 6 & 6 & 6 & 5 \\ 0 & 3 & 5 & 5 & 5 \\ 0 & 1 & 5 & 5 & 5 \end{bmatrix}$$