CSCE 633 : Machine Learning : HW4

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Question 1: Convolution Operation

Q1. Convolution with stride of 1 The Input is:

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

Filter is:

$$\begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix}$$

Hence, we get the convolution with stride 1 as:

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

Hence we get:

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

Q2. Zero padding of 1 + convolution with stride of 1
with zero padding and stride 1 we get:

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

Now with the filter on and stride 1:

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

Hence finally we get:

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

Q3. Zero padding of 2 + convolution with stride of 2
with zero padding of 2 and stride of 2:

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

Hence with filter application we get:

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

So we finally get:

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

Q4. Convolution with stride of 1 + max pooling of 3 with stride of 1
we get the convolution with stride 1 as:

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

Hence we get:

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

Finally with a pooling of 3x3 and stride of 1 we get: [6]

Q5. Zero padding of 2 + convolution with stride of 1 + max pooling of 3 with stride of 1
with zero padding of 2 and stride of 2:

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

We apply filter with stride of 1 and get:

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

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

Hence finally we get after pooling of 3 and stride 1:

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