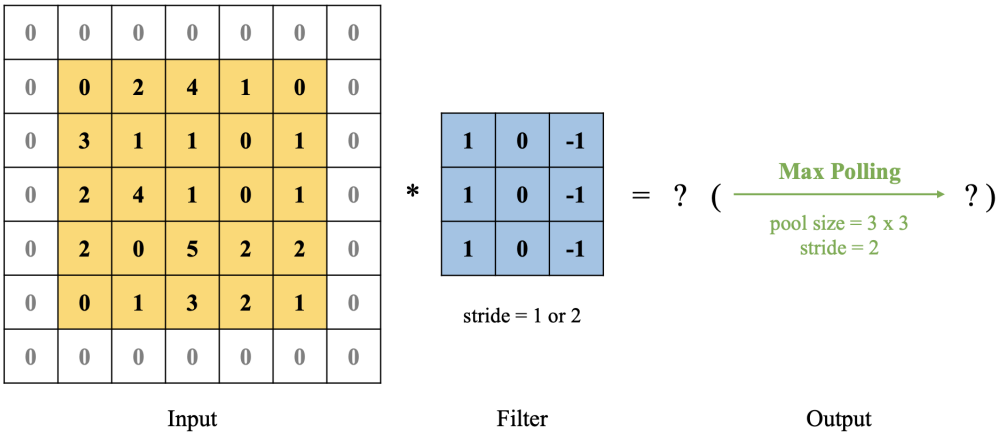
Homework 6: Convolutional Neural Network **CSCE 633**
Due: 11:59pm on April 12, 2024

Instructions for homework submission
a) For each question, please explain your thought process, results, and observations in a markdown cell after the code cells. Please do not just include your code without justification.
b) **You can use any available libraries for this homework.**

Question 1: Convolution Operation

In this problem, we will use the convolution operation on the matrix using the 3x3 filter as shown below.



Apply the convolution operation for all the following settings respectively, and write your outputs in a markdown cell.

- without max pooling and with stride of 1
- without max pooling and with stride of 2
- with max pooling and with stride of 1

Question 2: Image Classification using CNN

(a) Dataloader Download the MNIST dataset and get the dataloader in PyTorch.

(b) Data Exploration Pick one example from each digit and visualize them. Count the number of samples per digit in the original training data.

(c) Modeling Implement a Convolutional Neural Network model using Convolution layers to classify the digits in the MNIST dataset.

(1) Split original training data (60000 datapoints) into training and validation datasets. We also have a test dataset (10000 datapoints).

(2) Visualize the filter in each layer.

(3) Monitor the loss on the training dataset across the epochs of the CNN training. Report the overall classification accuracy on validation dataset.

(4) Use validation dataset to tune the hyper-parameters of the model. You may experiment on the validation set with different CNN hyper-parameters, e.g. num of layers, filter size, stride, activation function, dropout, weight regularization, etc. You may also try different loss functions and optimization methods.

(5) Use the best fine-tuned model for inference on test dataset. Compare the classification accuracy result with the model you had in **step 3** above.