VARIANTS OF THE BASIC CONVOLUTION FUNCTION:

In practical implementations of the convolution operation, certain modifications are made which deviate from standard discrete convolution operation:

• In general a convolution layer consists of application of several different kernels to the input. Since, convolution with a single kernel can extract only one kind of feature.

• The input is generally not real-valued but instead vector valued.

• Multi-channel convolutions are commutative if number of output and input channels is the same.

Effect of Strides

• Stride is the number of pixels shifts over the input matrix.

• In order to allow for calculation of features at a coarser level strided convolutions can be used.

• The effect of strided convolution is the same as that of a convolution followed by a down sampling stage.

• Strides can be used to reduce the representation size.

• Below is an example representing 2-D Convolution, with (3 × 3) Kernel and Stride of 2 units.

Effect of Zero Padding

• Convolution networks can implicitly zero pad the input V, to make it wider.

• Without zero padding, the width of representation shrinks by one pixel less than the kernel width at each layer.

• Zero padding the input allows to control kernel width and size of output independently.

Zero Padding Strategies

3 common zero padding strategies are:

a)Valid Zero Padding

1. No zero padding is used.
2. Output is computed only at places where entire kernel lies inside the input.
3. Shrinkage > 0.
4. Limits number of convolution layers to be used in network.

5. Input's width = m, Kernel's width = k,
   Width of Output = m − k + 1.

b)Same Zero Padding

1. Just enough zero padding is added to keep:
   Size (Output) = Size (Input).
2. Input is padded by (k − 1) zeros.
3. Since the number of output units connected to border pixels is less than that for center pixels, it may under-represent border pixels.
4. Can add as many convolution layers as hardware can support.
5. Input's width = m, Kernel's width = k,
   Width of Output = m.

c)Strong Zero Padding

1. The input is padded by enough zeros such that each input pixel is connected to the same number of output units.
2. Allows us to make an arbitrarily deep neural network.
3. Can add as many convolution layers as hardware can support.
4. Input's width = m, Kernel's width = k,
   Width of Output = m + k − 1.

TYPES OF CONVOLUTION

Unshared Convolution

Properties:

1. No parameter sharing.
2. Each output unit performs a linear operation on its neighborhood but parameters are not shared across output units.
3. Captures local connectivity while allowing different features to be computed at different spatial locations.

Advantages:

1. Reducing memory consumption.
2. Increasing statistical efficiency.
3. Reducing the amount of computation needed to perform forward and back-propagation.

Disadvantages:

1. Requires much more parameters than the convolution operation.

Tiled Convolution

Properties:

1. Offers a compromise between unshared and traditional convolution.
2. Learns a set of kernels and cycles/rotates them through space.
3. Makes use of parameter sharing.

Advantages:

1. Reduces the number of parameters in the model.

Traditional Convolution

Properties:

1. Equivalent to tiled convolution with t = 1.
2. Has the same connectivity as unshared convolution.

Examples of Unshared, Tiled and Traditional Convolutions

1. Unshared Convolution:
   Different weight parameters are used for different spatial locations. There is no parameter sharing.