Digital Image Processing

Assignment 01

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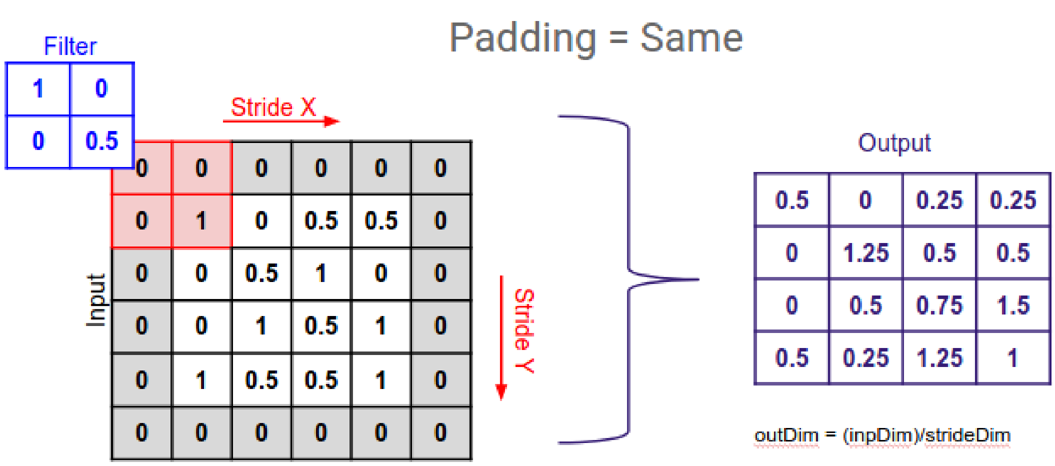
What is padding?

Ans: Padding extends the area of an image in which a convolutional neural network processes. The kernel/filter which moves across the image scans each pixel and converts the image into a smaller image. To work the kernel with processing in the image, padding is added to the outer frame of the image to allow for more space for the filter to cover in the image. Adding padding to an image processed by a CNN allows for a more accurate analysis of images. Padding is simply a process of adding layers of zeros to our input images to avoid the problems mentioned above.

Padding refers to the space between the content of an image or cell and its perimeter. It is an area surrounding the text that is padding. This is the yellow area below. A column is covered in padding between the top, bottom, right and left sections of the content. With image padding, new pixels are added around the edges of images. When performing advanced filtering, the border acts as a boundary to annotations or acts as a channel for separating images.



There are three types of padding:

1. **Same padding:** In this type of padding, the padding layers append zero values in the outer frame of the images or data so the filter we are using can cover the edge of the matrix and make the inference with them too.

2. **Causal padding:** This is a special type of padding and works with the one-dimensional convolutional layers. We can use them majorly in time series analysis. Since a time series is a sequential data it helps in adding zeros at the start of the data. Which also helps in predicting the values of early time steps.
3. **Valid padding:** This type of padding can be considered as no padding.

Why is padding required?

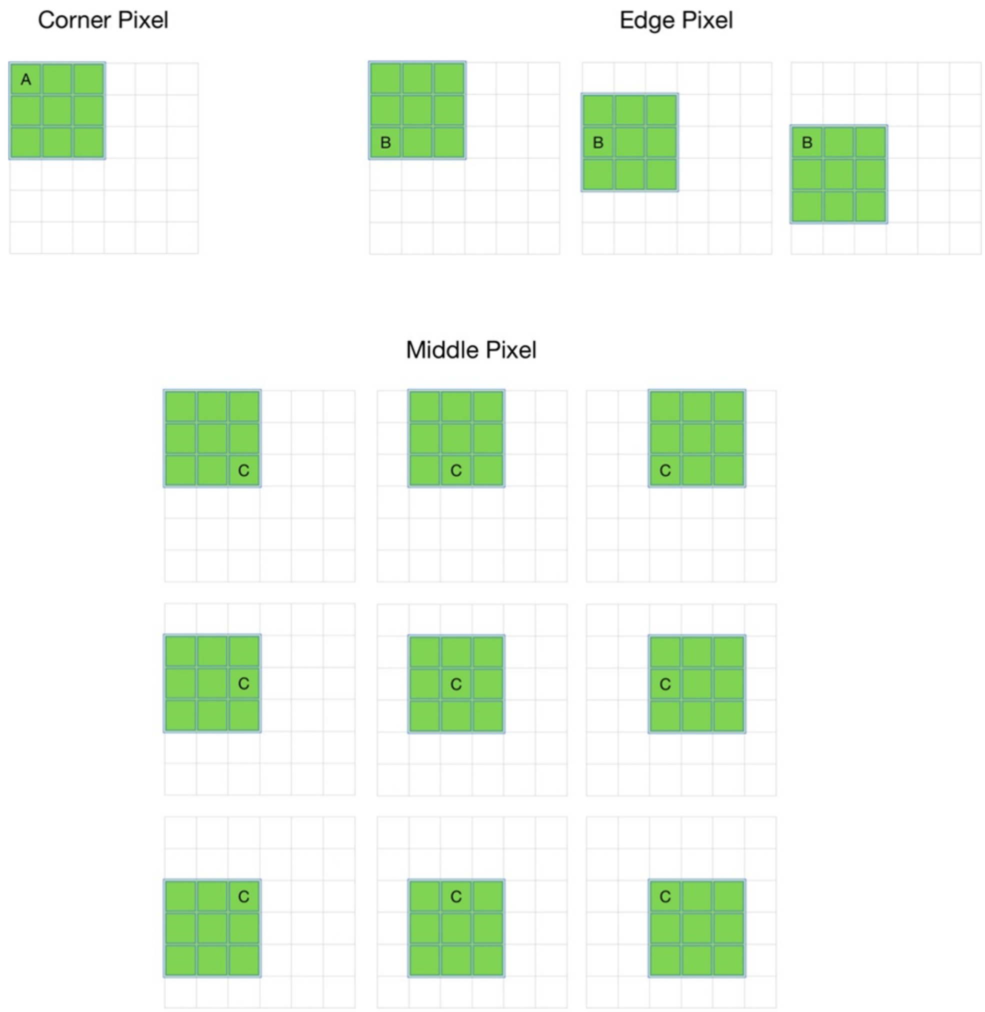
Ans: To work the kernel with processing in the image, padding is added to the outer frame of the image to allow for more space for the filter to cover in the image. Adding padding to an image processed by a CNN allows for a more accurate analysis of images. A padding effect is added to the frame of the image that allows more space for the kernel to cover the image to aid the kernel in handling it. An image can be analyzed more accurately by padding it when it is processed by CNN. padding areas provide information that describes where the elements intersect. Whenever padding is applied to an element, it creates additional space. By contrast, the margin in a standard element creates extra space.

It is also required to maintain the size of the image as it is. When the operations/filter is applied to the image. The pixels at the corners and the edges are used less as compared to other pixels of the image. So the features of the image that are at the edges are not captured by the filter. Using padding these features can be used more by the filter in the enhanced image.

1. Padding is required to preserve the features of an image after performing the operations.
2. It is also required to maintain the size of the image as it is.
3. When the operations/filter is applied to the image. The pixels at the corners and the edges are used less as compared to other pixels of the image. So the features of the image that are at the edges are not captured by the filter.

Using padding these features can be used more by the filter in the enhanced image.

4. For a gray scale (n x n) image and (f x f) filter/kernel, the dimensions of the image resulting from a convolution operation is (n – f + 1) x (n – f + 1).
5. For example, for an (8 x 8) image and (3 x 3) filter, the output resulting after convolution operation would be of size (6 x 6). Thus, the image shrinks every time a convolution operation is performed. This places an upper limit on the number of times such an operation could be performed before the image reduces to nothing thereby precluding us from building deeper networks.



6. The above image is an example of the movement of a filter of size (3 x 3) on an image of size (6 x 6). We can see that a corner pixel A is coming under the

filter in only one movement where b is coming in three movements and c is coming under 9 movements.

7. It shows that the kernel will work with pixel C very fine and it will misinterpret pixel A. This will cause the loss of information available in the corners and also the output from the layers is reduced and reduced information will create confusion for the next layers. This problem can be reduced by the padding layers.
8. A padding effect is added to the frame of the image that allows more space for the kernel to cover the image to aid the kernel in handling it. An image can be analyzed more accurately by padding it when it is processed by CNN.

Consider images of size NxN. Apply various image enhancement techniques. Show that padding is essential or otherwise. Comment on the cases/images where padding is not essential.

Ans:

Cases where padding is not essential:

- When the image enhancement technique is applied greater or the intensity of the image rather than dependency upon the spatial ordering of pixels

  Eg: Histogram equalization does not require an image to be padded

- During image compression, an image with padding might add redundant values in the Fourier transform of the image
- For images with uniform or continuous values along the edges instead of zero-padding, the same pixel values along the image boundary can be extended while applying a filter.

Consider a filter of size 3x3 to be applied to an image of size 5x5. Various image enhancement techniques can be applied.

1. **Smoothing linear filter**

1/9 x | 1 1 1 | and 1/16 x | 1 2 1 |

| 1 1 1 | | 2 4 2 |

| 1 1 1 | | 1 2 1 |

2. **Sharepening filter**

|0 1 0| |1 1 1|

|1 -4 1| |1 -8 1|

|0 1 0| |1 1 1|

|0 -1 0| |-1 -1 -1|

|1 4 1| |-1 8 -1|

|0 -1 0| |-1 -1 -1|

3. **Non linear filter**

|-1 -2 -1| |-1 0 1|

|0 0 0| |-2 0 2|

|1 2 1| |-1 0 1|

Applying smoothing linear filter

Let I = | 0 0 0 0 0 |

| 0 0 0 0 0 |

| 0 0 0 0 0 |

| 0 0 0 0 0 |

| 0 0 0 0 0 |

| 0 0 0 0 0 |

Be the 5x5 base image and

K = |1 2 1|

|2 4 2|

|1 2 1|

Be the 3x3 kernel to be applied

First, the image needs to be padded with a minimum of 3-1 = 2 rows at the top and bottom and 3-1 = 2 columns to the left and right as the filter size is 3x3.

I = | 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

Applying the kernel K on I

K*I = | 1 2 1 0 0 0 0 0 0 |

| 2 4 2 0 0 0 0 0 0 |

| 1 2 1 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

Thus we can see that the entire kernel could be fit into the image because of the padding.

Now applying the padding throughout we get

I = | 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 1 2 1 0 0 0 |

| 0 0 0 2 4 2 0 0 0 |

| 0 0 0 1 2 1 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

| 0 0 0 0 0 0 0 0 0 |

Creeping the padded image

I = | 0 0 0 0 0 |

| 0 1 2 1 0 |

| 0 2 4 2 0 |

| 0 1 2 1 0 |

| 0 0 0 0 0 |

Thus with the help of padding, the kernel has been applied successfully. The padding is not required here if the kernel size is |x|.