Digital Image Processing

Assignment 1

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What is padding? Why is padding required? 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.

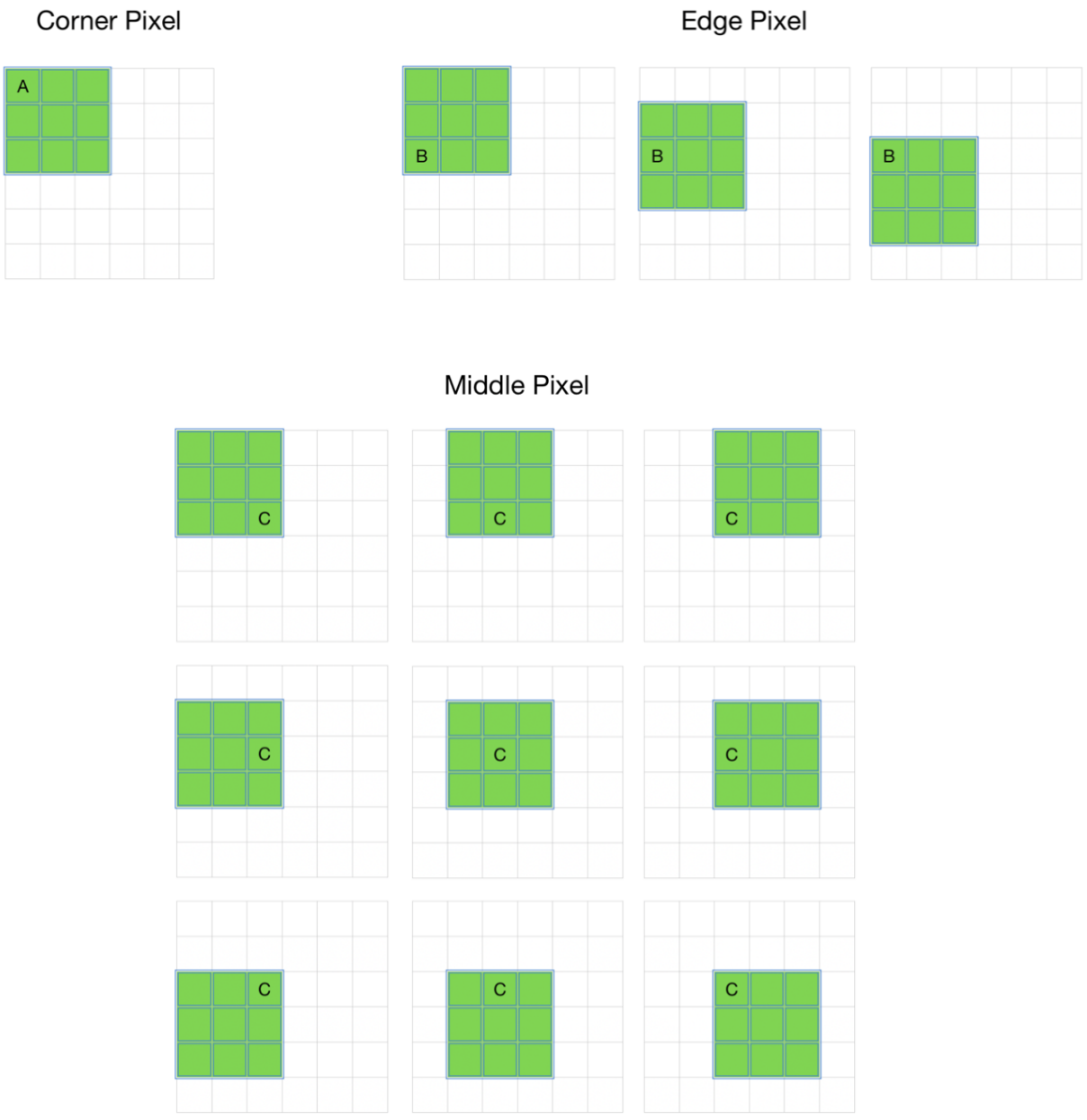
Padding

1. Padding basically extends the area of an image that is processed.
2. The kernel/filter which moves across the image scans each pixel and converts the image into a smaller image.
3. In order 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 the image.
4. The types of padding are as follows
    a. **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.
    b. **Valid padding**: This type of padding can be considered as no padding. The input image is left in its valid/unaltered shape.

Why is padding needed?

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 $(n - f + 1) \times (n - f + 1)$.
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. Also, the pixels on the corners and the edges are used much less than those in the middle.
7.



8. 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 clearly 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.

9. It basically 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.
10. A padding effect is added to the frame of the image that allows more space for the kernel to cover the image in order to aid the kernel in handling it. An image can be analyzed more accurately by padding it when it is processed by CNN.

Cases/images where padding is not essential

1. Multiplication in the frequency domain corresponds with circular convolution in the spatial domain. This means that without padding the image properly, results from one side of the image will wrap around to the other side of the image.
2. You can think of 2D filtering as a sliding window that is centered over each pixel in the image and the center output pixel is a weighted sum of the pixels in the window. With circular convolution, when the window hangs over the right edge of the image, it is actually wrapping back around to the left side of the image. This means that output pixels on the right edge of the image will be affected by pixels on the left edge, which is almost never what is actually desired.
3. Zero-padding allows space for this wrap-around to occur without contaminating actual output pixels.