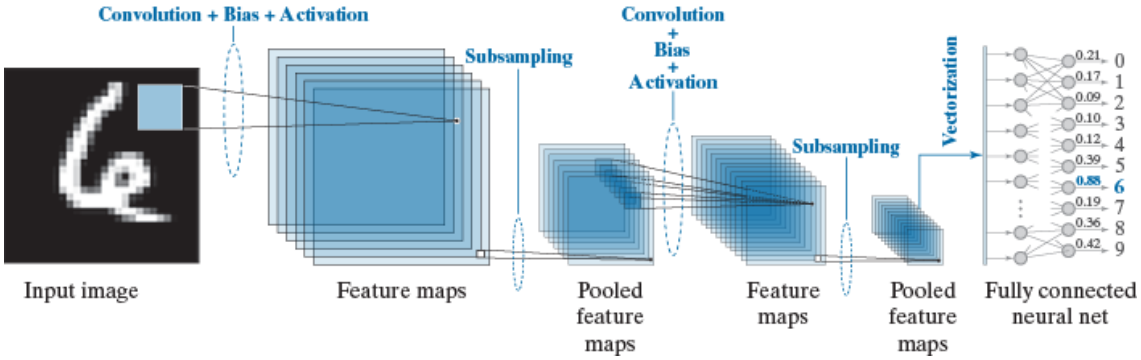
Homework 4- 05/26/2023 (110%)

作業四之繳交期限: 6/2/2023 10:10AM

Please remember to write down your name and student number.

The procedures leading to your answers are required to grade.

1. (45%) For the CNN below, there are 6 feature maps for the first layer and 12 feature maps for the second layer. The receptive field is 7x7. And, 2x2 average pooling neighborhood is used. Suppose that the size of an input image (greyscale) is 66x66.



   (a) (5%) Describe the definition of "stride" in a CNN.

   (b) (5%) Describe the definition of "receptive field" in a CNN.

   (c) (5%) What does "weight sharing" mean in a LeNet?

   (d) (10%) What are the spatial resolutions of the feature maps in the first layer and in the second layer, respectively? What are the resolution of the pooled feature maps in the first layer and in the second layer, respectively?

   (e) (10%) According to what we taught in the class, calculate the number of the parameters to generate the feature maps in the first layer. Similarly, calculate the number of the parameters to generate the feature maps in the second layer.

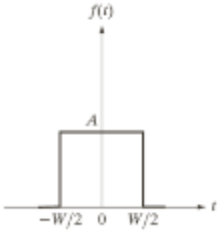
   (f) (10%) Use the chain rule to relate to the adjacent layers for the calculation of the following delta function: $\delta_{x,y}(\ell) = \frac{\partial E}{\partial z_{x,y}(\ell)} = ?$

2. (10%) The continuous Fourier Transform of one-variable function *f(x)* is defined as

$$F(u) = \int_{-\infty}^{\infty} f(x) e^{-j2\pi ux} dx .$$

   (a) (6%) Derive the Fourier transform of *f(t)* shown below.

   (b) (4%) Draw its **phase** of its Fourier transform.



3. (30%) The discrete Fourier Transform of two-variable function *f(x,y)* is defined as

$$F(u,v)=\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)e^{-j2\pi(ux/\mathrm{M}+\mathrm{vy/N})}\ u=0,1,2,...M-1; v=0,...,N-1.$$

(a) (5%) Explain how to obtain the average of a function if the DFT of that function is available. The function is not known and IDFT cannot be used.

(b) (10%) Prove that $f(x,y)$ is real and even $\Leftrightarrow$ *F(u,v)* is real and even .

(c) (10%) Show that the following equation is valid.

$$\Im\left[f(x,y)(-1)^{x+y}\right]=F(u-\frac{M}{2},v-\frac{N}{2})$$

(d) (5%) Describe the purpose of zero-padding before doing DFT on an image? What is its potential problem of zero-padding?

4. (15%) The steps for filtering in freq. domain are as follows. Filling in the underline parts.

(a) (2%) Given an image *f(x,y)* of size *MxN*, obtain the padding parameters *P*=_____, *Q*=_____

(b) (0%) Form a padding image $f_p(x,y)$, of size PxQ by appending the necessary number of zeros to f(x,y)

(c) (0%) Multiply $f_p(x,y)$ by $(-1)^{x+y}$ to center its transform

(d) (0%) Compute the DFT F(u,v) of $f_p(x,y)$

(e) (3%) Generate a _____, _____ filter function H(u,v) of size PxQ

(f) (3%) Form G(u,v)= _____

(g) (4%) Obtain the processed image $g_p(x,y)$ by

$$g_p(x,y)=\{\_\_\_\_[\Im^{-1}[G(u,v)]]\}(-1)^{x+y}$$

(h) (3%) Extracting the MxN region from the _____ of $g_p(x,y)$

5. (10%) Consider the following intensity matrix of a 5x5 image A. The depth of a pixel is 3 bits.

Image A

3	5	4	6	5
5	4	3	4	5
4	4	**2**	3	7
3	2	2	3	5
0	1	1	2	4

Image B

0	1	2	3	4
2	4	5	6	5
4	6	7	5	6
2	4	5	7	5
0	1	2	3	4

(a) (5%) For image A, what is the intensity matrix of the histogram-equalized image?

(b) (5%) For image A, what is the intensity matrix of the histogram-matched image such that the output image has a histogram of the shape similar to what image B has?