RYERSON UNIVERSITY

Faculty of Engineering, Architecture, and Science

Department of Electrical and Computer Engineering

Course Number	EE8603
Course Title	Neural Networks and Deep Learning
Semester/Year	Summer/2018

Instructor	Dr. Kandasamy Illanko

Assignment No. 5

Assignment Title	Convolutional Neural Networks

Submission Date	17^{th} July 2018
Due Date	17^{th} July 2018

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Signature*	

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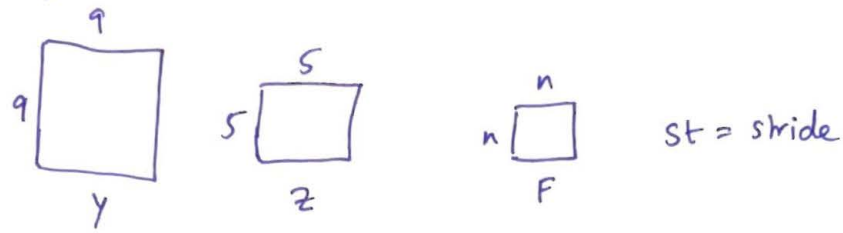
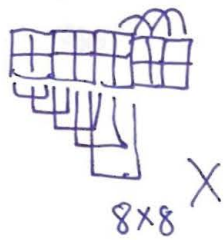
Exercise 1)



st = stride

n = ? st = ?

n = 2, st = 1



X

n = 2, st = 2

X

Determining Formula :-

T = Total # of strides to be taken = $\left(\frac{Y\_width - n}{st}\right)$

$$2 = \frac{T}{st} + 1 = \frac{(Y\_width - n)}{st} + 1$$

$$\therefore \quad 5 = \left(\frac{9 - n}{st}\right) + 1$$

$$4 = \frac{9 - n}{st}$$

$$4st = 9 - n$$

$$4st - 9 = -n$$

$$n = 9 - 4st$$

if st = 1

$$n = 9 - 4 = 5$$

if st = 2

$$n = 9 - 4(2) = 1$$

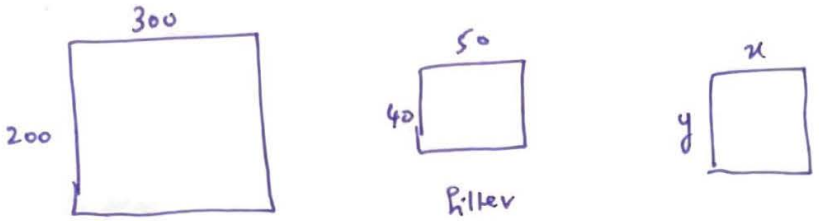
$\therefore$ n = 1, st = 2

or

n = 5, st = 1

5x5 filter with stride = 1

Exersice 2)



Feature map
Y

st = 10
F

Z

Using formula:-

$$Z_{width} = \frac{Y_{width} - F_{width}}{st} + 1$$

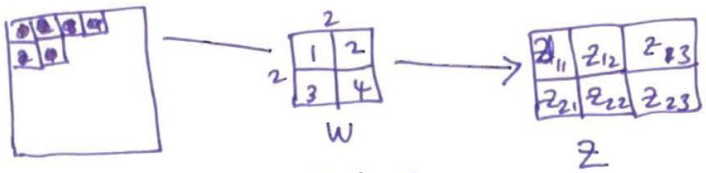
$$Z_{width} = \frac{300 - 50}{10} + 1 = \frac{250}{10} + 1 = 26$$

$$Z_{height} = \frac{Y_{height} - F_{height}}{st} + 1$$

$$Z_{height} = \frac{200 - 40}{10} + 1 = \frac{160}{10} + 1 = 16 + 1 = 17$$

$\therefore$ $Z(width, height) = Z(26, 17)$

Exersice 3)



$2 \times 2 = 4$

$z_{23} \Rightarrow y$

$y' \Rightarrow \begin{bmatrix} y_{35} & y_{36} \\ y_{45} & y_{46} \end{bmatrix} \Rightarrow \begin{bmatrix} y'_{11} & y'_{12} \\ y'_{21} & y'_{22} \end{bmatrix}$

$$\frac{\partial z_{23}}{\partial w} = \sum_{i,j} \frac{\partial z_{23}}{\partial y_{ij}} \frac{\partial y_{ij}}{\partial w}$$

$$\frac{\partial z_{23}}{\partial w} = \frac{\partial z_{23}}{\partial y'_{11}} \frac{\partial y'_{11}}{\partial w} + \frac{\partial z_{23}}{\partial y'_{12}} \frac{\partial y'_{12}}{\partial w} + \frac{\partial z_{23}}{\partial y'_{21}} \frac{\partial y'_{21}}{\partial w} + \frac{\partial z_{23}}{\partial y'_{22}} \frac{\partial y'_{22}}{\partial w}$$

$$= w_{11} \frac{\partial y'_{11}}{\partial w} + w_{12} \frac{\partial y'_{12}}{\partial w} + w_{21} \frac{\partial y'_{21}}{\partial w} + w_{22} \frac{\partial y'_{22}}{\partial w}$$

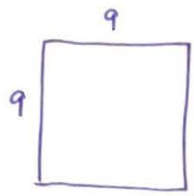
$$= 1\,(y_{35}) + 2\,(y_{36}) + 3\,(y_{45}) + 4\,(y_{46})$$

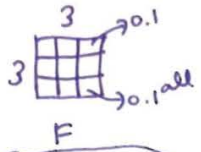
$$= 1(8) + 2(9) + 3(9) + 4(10)$$

$$= 8 + 18 + 27 + 40$$

$$\frac{\partial z_{23}}{\partial w} = 93$$

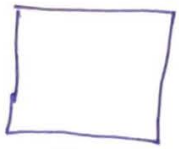
Exersice 4)

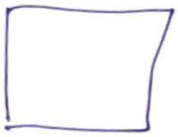




stride = 2

b = 0





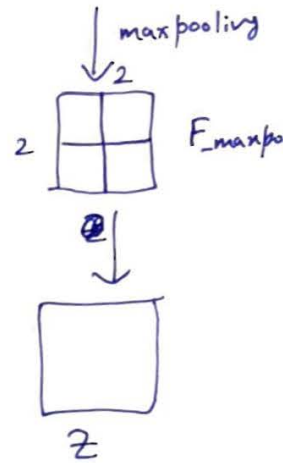
$y(i,j) = (-1)^{i+1}(i+1)$

$Y \Rightarrow$

	1	2	3	4	5	6	7	8	9
1	2	3	4	5	6	7	8	9	10
2	-2	-3	-4	-5	-6	-7	-8	-9	-10
3	2	3	4	5	6	7	8	9	10
4	-2	-3	-4	-5	-6	-7	-8	-9	-10
5	2	3	4	5	6	7	8	9	10
6	-2	-3	-4	-5	-6	-7	-8	-9	-10
7	2	3	4	5	6	7	8	9	10
8	-2	-3	-4	-5	-6	-7	-8	-9	-10
9	2	3	4	5	6	7	8	9	10

$Y_1 \Rightarrow$

	1	2	3	4
1	0.9	1.5	2.1	2.7
2	0.9	1.5	2.1	2.7
3	0.9	1.5	2.1	2.7
4	0.9	1.5	2.1	2.7



$Y_{1(1,1)} = (2 \times 0.1) + (3 \times 0.1) + (4 \times 0.1) + (-2 \times 0.1) + (-3 \times 0.1) + (-4 \times 0.1) + (2 \times 0.1) + (3 \times 0.1) + (4 \times 0.1)$

$= 0.2 + 0.3 + 0.4 = 0.9 = Y_{1(1,2)} = Y_{1(1,3)} = Y_{1(1,4)}$

$Y_{1(2,1)} = (4 \times 0.1) + (5 \times 0.1) + (6 \times 0.1) = 0.4 + 0.5 + 0.6 = 1.5 = Y_{1(2,2)} = Y_{1(2,3)} = Y_{1(2,4)}$

$Y_{1(3,1)} = (6 \times 0.1) + (7 \times 0.1) + (8 \times 0.1) = 0.6 + 0.7 + 0.8 = 2.1 = Y_{1(3,2)} = Y_{1(3,3)} = Y_{1(3,4)}$

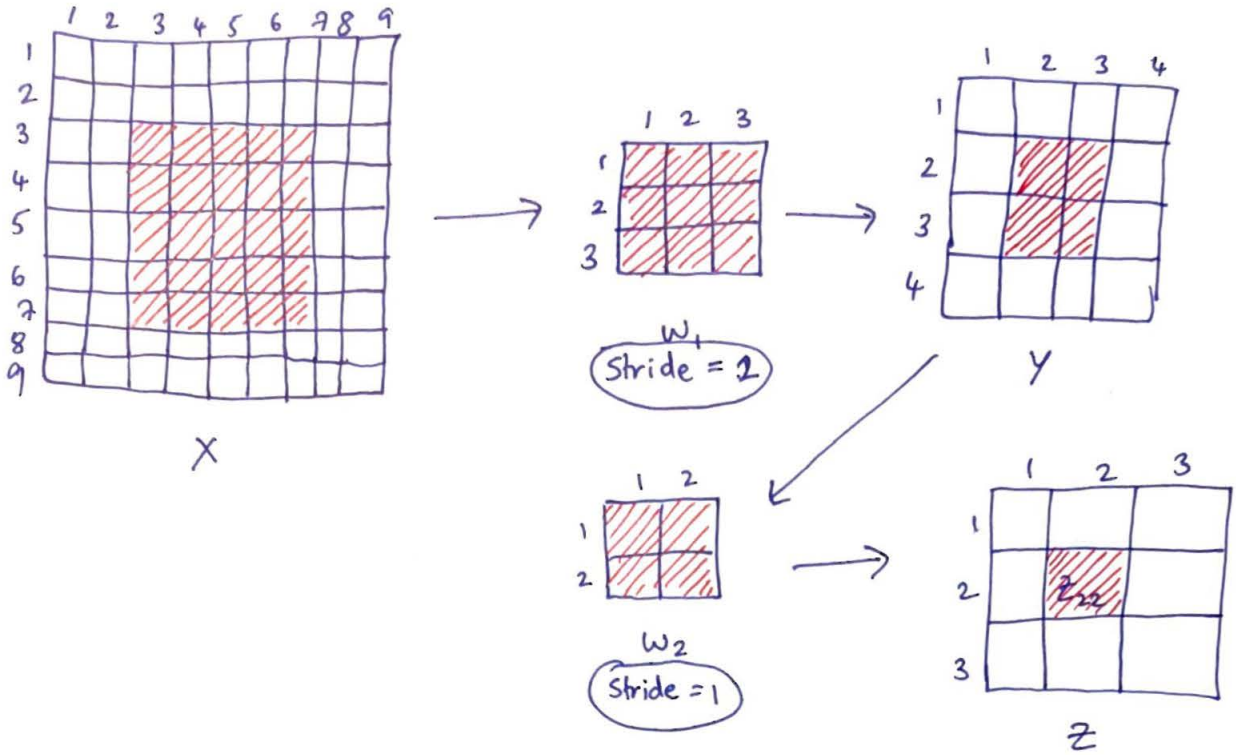
$Y_{1(4,1)} = (8 \times 0.1) + (9 \times 0.1) + (10 \times 0.1) = 0.8 + 0.9 + 1 = 2.7$

$Y_1 = Y_2$ because Y_1 does not contain any negative values.

$Z \Rightarrow$

1.5	2.7
1.5	2.7

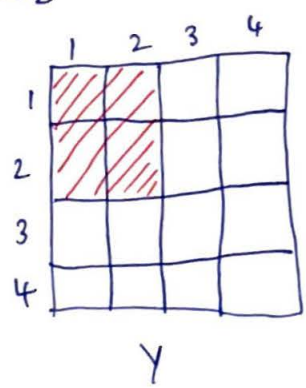
(a)

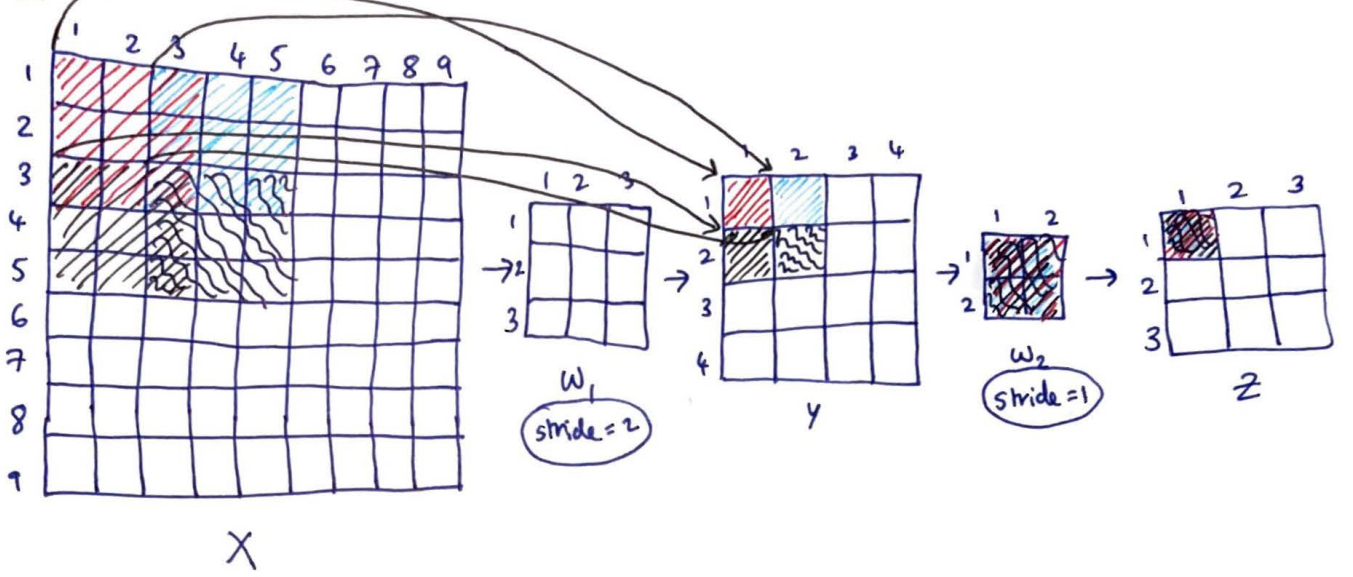


Dimensions of Y = $\frac{X\_width - W_1\_width}{Stride} + 1 = \frac{9-3}{2} + 1 = 4$

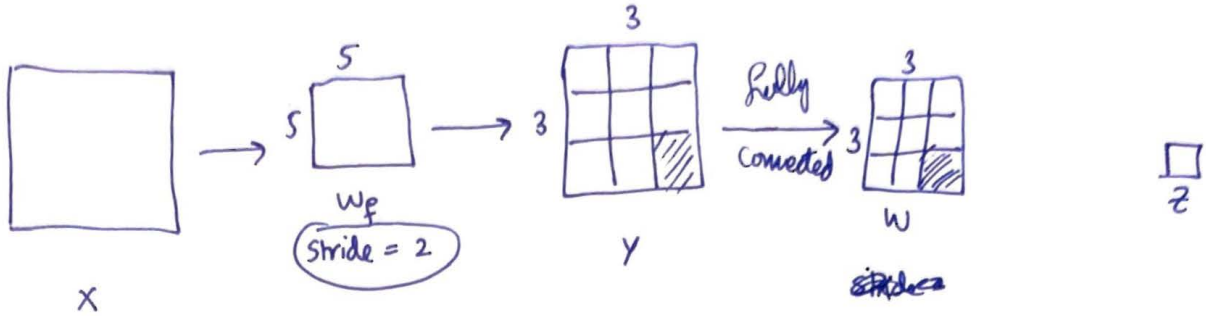
Dimensions of Z = $\frac{Y\_width - W_2\_width}{Stride} + 1 = \frac{4-2}{1} + 1 = 3$

(b) $\frac{\partial z_{11}}{\partial W_2} = Y(1,1) + Y(1,2) + Y(2,1) + Y(2,2)$




X
W1
stride = 2
Y
W2
stride = 1
Z

Exercise 6)



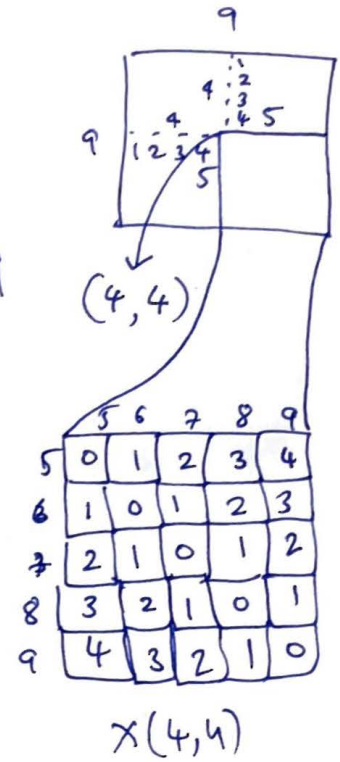
$x(i,j) = |i-j|$

$w(i,j) = i+j-1$

$\frac{\partial z}{\partial w_f}(3,3)$?

Size of X ?

$X\_width = X\_height =$ [illegible]



$$\frac{\partial z}{\partial w_f}(3,3) = \frac{\partial z}{\partial y_{33}} \frac{\partial y_{33}}{\partial w_f}$$

$$= w(3,3)\, X_{wf}(4,4)$$

$$= (3+3-1)\, X_{wf}(4,4)$$

$$= 5 \begin{bmatrix} 0 & 1 & 2 & 3 & 4 \\ 1 & 0 & 1 & 2 & 3 \\ 2 & 1 & 0 & 1 & 2 \\ 3 & 2 & 1 & 0 & 1 \\ 4 & 3 & 2 & 1 & 0 \end{bmatrix}$$

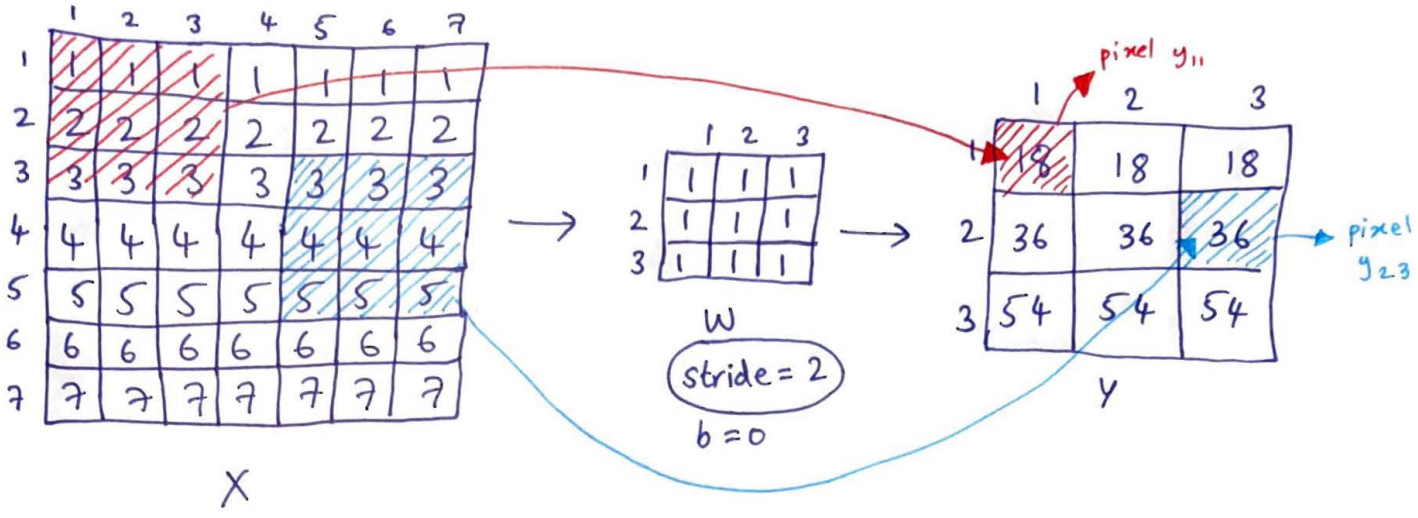
$$= \begin{bmatrix} 0 & 5 & 10 & 15 & 20 \\ 5 & 0 & 5 & 10 & 15 \\ 10 & 5 & 0 & 5 & 10 \\ 15 & 10 & 5 & 0 & 5 \\ 20 & 15 & 10 & 5 & 0 \end{bmatrix}$$

Exercise 9)

(a)

(b)

(c)



1 EXERCISE 7

The function $featureMap$ takes in the filter, stride amount, bias and original feature map and applies the filter to create the resultant feature map.

1.1 MATLAB CODE TESTEFESTUREMAP

```
k = 8; % Last digit of my student ID
m = 200+(10*k);
n = 150;
stride = 10;
bias = 1;
X = k*ones(m,n);
W = rand(30,20);
Y = featureMap(X,W,bias,stride);
disp('X:');
disp(X);
disp('Y:');
disp(Y);
```

1.2 CODE OUTPUT

```
Y:
   1.0e+03 *

    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465
    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465
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    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465
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    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465
    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465
    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465    2.4465
```

Figure 1.1: The result agree with part a and b.

X is too large to show in picture, here is the workspace variable sizes:

Workspace

Name ▲	Value
bias	1
k	8
m	280
n	150
stride	10
W	30x20 double
X	280x150 double
Y	26x14 double

2 Exercise 8

2.1 MATLAB Code testCNNout

```
myPic_RAW = imread('inimg.jpg');
myPic = imresize(myPic_RAW,[628 418]);
cF=cell(1,3);
%%%   Deal with other filters here.    %%%%%
cF{1}=0.5*ones(20,30) - rand(20,30);
cF{2}=0.5*ones(10,14) - rand(10,14);
cF{3}=0.5*ones(3,4) - rand(3,4);
%%%%%   Deal with the stride and bias arrays  here.    %%%%%%
strides = [2 2 1];
biases = rand(3,1) - 0.5;
%%% red color  %%%
X1=myPic(:,:,1);
fM1=CNNout(X1,cF,biases,strides);
%%% green color  %%%
X2=myPic(:,:,2);
fM2=CNNout(X2,cF,biases,strides);
%%% green color  %%%
X3=myPic(:,:,3);
fM3=CNNout(X3,cF,biases,strides);
fM=cell(1,3);
fM{1}=fM1;
fM{2}=fM2;
fM{3}=fM3;
save('result.mat',fM);
```

3 EXERCISE 9

3.1 PART D

```
>> exersice_9
dy_11/dW:
     1     1     1
     2     2     2
     3     3     3

dy_23/dW:
     3     3     3
     4     4     4
     5     5     5
```

Figure 3.1: The result agree with part a and b.

3.2 PART E

```
x_width = 7;
x_height = 7;
X = ones(x_width,x_height);
for i =1:x_height
    for j=1:x_width
        X(i,j) = i;
    end
end
D = dfeatureMap(X,3,3,2);
disp('dy_11/dW:')
disp(D(:,:,1,1))
disp('dy_23/dW:')
disp(D(:,:,2,3))
```