CSC 578-701 Loop Quiz #4
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1. If a convolution layer accepts a volume of size W1*H1*D1 as input and the hyperparameters are:
    - K = number of filters,
    - F = their spatial extent,
    - S = the Stride,
    - P = the amount of zero padding.

    This layer produces a volume of size W2*H2*D2. Give a formula for W2, H2, D2 (one for each).

    Terminology references: [1], [2]

Solutions:

W2 = $\frac{W1-F+2P}{S}$+1

H2 = $\frac{H1-F+2P}{S}$ +1

D2 = K

2. If the input image is 32*32, the filter is 3*3, the stride is 1 and there are 100 filters. Find the size of feature map (including depth) and the total number of parameters.

Solutions:

Input size: [32*32], F=3*3, S=1, P=0, and K=100.

W2 = (32−3)/1+1=30

H2 = (32-3)/1+1 = 30

D2 = 100

The size of the feature map output volume is (3*3*1+1)*100, i.e. 1000.

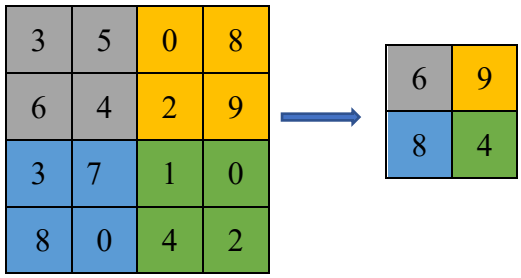
3. Explain Pooling and Max Pooling with an example (one for each).

Solutions:

Pool Layer performs a function to reduce the spatial dimensions of the input, and the computational complexity of our model. And it also controls overfitting. It operates

independently on every depth slice of the input. Max pooling is the most used type of pooling which only takes the most important part (the value of the largest pixel) of the input volume.

Example. Max pooling with 2x2 filter and stride = 2. So, for each of the windows, max pooling takes the max value of the 4 pixels.



Max pooling with 2x2 filter and stride = 2.

4. If a pooling layer accepts a volume of size W1*H1*D1 as input and the hyperparameters are:
   - F = their spatial extent,
   - S = the Stride,

   This layer produces a volume of size W2*H2*D2. Give a formula for W2, H2, D2 (one for each).

Solutions:

$W2 = \frac{W1-F}{S} + 1$

$H2 = \frac{H1-F}{S} + 1$

D2 = D1

5. For the Homework #3 base model:
   - [1st layer] Convolution -- 32 5x5 filters, stride (1,1), activation relu
   - [2nd layer] Max pooling -- size 2x2, stride (2,2)
   - [3rd layer] Convolution -- 32 5x5 filters, stride (1,1), activation relu
   - [4th layer] Max pooling -- size 2x2, stride (2,2)
   - [5th layer] Fully connected (Dense) -- 512 nodes, activation relu
   - [6th layer] Fully connected (Dense) -- 10 nodes, activation softmax

Also the model accepts input of size 32*32*3, exactly like HW#3.

Explain how each of the number of parameters ('Param #') is calculated in the following model summary.

```
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 28, 28, 32)        2432
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 14, 14, 32)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 10, 10, 32)        25632
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 5, 5, 32)          0
_________________________________________________________________
flatten_1 (Flatten)          (None, 800)               0
_________________________________________________________________
dense_1 (Dense)              (None, 512)               410112
_________________________________________________________________
dense_2 (Dense)              (None, 10)                5130
=================================================================
Total params: 443,306
Trainable params: 443,306
Non-trainable params: 0
```

Solutions:

Layer	Input size	F	S	K	Output W2	Output H2	Output D2	Param #
conv2d_1 (Conv2D)	32*32*3	5*5	1	32	(32-5)/1+1=28	(32-5)/1+1=28	32	(5*5*3+1)*32 =2432
max_pooling 2d_1	28*28*32	2*2	2	32	(28-2)/2+1=14	(28-2)/2+1=14	32	0
conv2d_2 (Conv2D)	14*14*32	5*5	1	32	(14-5)/1/+1=10	(14-5)/1/+1=10	32	(5*5*32+1) *32=25632
max_pooling 2d_2	10*10*32	2*2	2	32	(10-2)/2+1=5	(10-2)/2+1=5	32	0
flatten_1 (Flatten)								0
dense_1 (Dense)								(5*5*32+1)* 512=410112
dense_2 (Dense)								(512+1)*10= 5130
Total								2432+25632+ 410112+5130 =443306

Note: Param# = (filter size + bias) depth*