

50.021 Artificial Intelligence

Quiz 3

Student Name:

Student ID:

[Q1]. Answer all the following MCQ questions.

- a The below graph shows the accuracy of a trained 3-layer convolutional neural network vs the number of parameters (i.e. number of feature kernels). The trend suggests that as

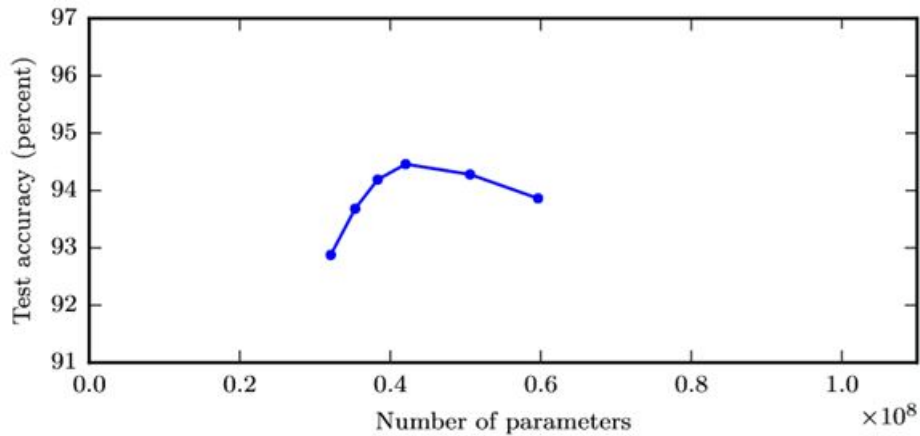


Figure 1: Training sample plots

you increase the width of a neural network, the accuracy increases till a certain threshold value, and then starts decreasing.

What could be the possible reason for this decrease?

- A. Even if number of kernels increase, only few of them are used for prediction
 - B. As the number of kernels increase, the predictive power of neural network decrease
 - C. As the number of kernels increase, the number of learnable parameters increase relative to the fixed number of training sample, and at some point overfitting sets in.
 - D. None of these
- b A convolutional neural network has 4 consecutive 3×3 convolutional layers with stride 1 and no pooling. How large is the set of image pixels which activate a neuron in the 4th non-image layer of this network? (Select one.)
- A. 9
 - B. 16
 - C. 49
 - D. 81
- c Consider one layer of weights (edges) in a convolutional neural network (CNN) for gray-scale images, connecting one layer of units to the next layer of units. Which type of layer has the fewest parameters to be learned during training? (Select one.)
- A. A max-pooling layer that reduces a 10×10 image to 5×5
 - B. A convolutional layer with 10 3×3 filters
 - C. A convolutional layer with 8 5×5 filters
 - D. A fully-connected layer from 20 hidden units to 4 output units

- d Which of the following are NOT true of convolutional neural networks (CNNs) for image analysis?
- A. Pooling layers reduce the spatial resolution of the image.
 - B. Convolutional neural networks are designed to be invariant to object position and distortion in the scene.
 - C. Convolutional neural nets combine only neighbor neurons into a neuron in the next layer.
 - D. Convolutional neural networks have more parameters than fully connected networks with the same number of layers and the same numbers of neurons in each layer.
- e Given that the input layer takes in a 7×7 image and the convolutional layer applies a 3×3 filter with stride 2 and the amount of zero padding used on the border is 1, what is the size of output?
- A. 3×3
 - B. 4×4
 - C. 5×5
 - D. 6×6

Solution: C D A D B

[Q2]. Figure 2 illustrates the before and after effect of a blurring filter when applied on a greyscale image. Blurring is an operation that makes strong edges weaker by some kind of averaging. Black pixels take a value of 0 and white pixels take a value of 1. Assume that the blurring effect is done using the following 5 by 5 filters with stride 1, and there's enough zero padding on the image before processing so that the filter will fit on the edges.

[8p] Determine whether each of the filters below can or cannot give a blurring effect and give your reason in not more than 2 sentences :

$$1. \frac{1}{10} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & -4 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Solution: False. This filter does some kind of edge detection. It is taking the difference between a pixel and its four neighbors.

$$2. \frac{1}{9} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Solution: True. This filter does normal averaging between neighbouring pixels, hence resulting in a blur effect.

$$3. \begin{bmatrix} 0 & 10 & 0 & 10 & 0 \\ 0 & 5 & 0 & 5 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & -5 & 0 & -5 & 0 \\ 0 & -10 & 0 & -10 & 0 \end{bmatrix}$$

Solution: False. This filter detects horizontal edges.

$$4. \frac{1}{159} \begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix}$$

Solution: True. This filter performs gaussian blur, or also known as a weighted average.



Figure 2: Blurring Filter Application

[Q3]. Given a CNN with the following layers:

1. Input layer : 2-channel of 10 by 20 pixels each.
2. Convolution layer: 10 of 3 by 5 filters each, with stride 2 and standard paddings.

*Note: for an odd-sized k by k kernel, standard padding adds on **every** side $(k - 1)/2$ rows or columns.*

In total, how many neurons are there in the convolution layer?

Solution:

Amount of padded columns is $\frac{5-1}{2} = 2$

Width of each convolution layer slice is $\lceil \frac{20-5+2 \cdot 2}{2} \rceil = 10$

Amount of padded rows is $\frac{3-1}{2} = 1$

Length of each convolution layer slice is $\lceil \frac{10-3+2 \cdot 1}{2} \rceil = 5$

Total number of neurons in convolution layer is $10 \times 5 \times 10 = 500$