CS640 Homework 3: Convolutional Neural Networks

In this assignment, you will be asked about some questions related to Convolutional Neural Networks (CNN).

For all questions, **provide calculation steps and/or some reasoning**.

Collaboration

You must answer written questions independently.

Instructions

General Instructions

In an ipython notebook, to run code in a cell or to render Markdown+LaTeX press `Ctrl+Enter` or `[>|]` (like "play") button above. To edit any code or text cell (double) click on its content. To change cell type, choose "Markdown" or "Code" in the drop-down menu above.

Most of the written questions are followed up a cell for you enter your answers. Please enter your answers in a new line below the **Answer** mark. If you do not see such cell, please insert one by yourself. Your answers and the questions should **not** be in the same cell.

Instructions on Math

Some questions require you to enter math expressions. To enter your solutions, put down your derivations into the corresponding cells below using LaTeX. Show all steps when proving statements. If you are not familiar with LaTeX, you should look at some tutorials and at the examples listed below between $..$. The OEIS website can also be helpful.

Alternatively, you can scan your work from paper and insert the image(s) in a text cell.

Submission

Once you are ready, save the note book as PDF file (File -> Print -> Save as PDF) and submit via Gradescope.

Please select pages to match the questions on Gradescope. **You may be subject to a 5% penalty if you do not do so**.

Q0: Name(s)

Please write your name in the next cell.

Answer

Q1

Consider a 1D convolution of a vector $[6, 3, 6]$ and filter $[2, 2, 1]$ with stride 1. Additionally, a ReLU activation is applied after the convolution. Calculate the final result.

Answer

Convolution: $[6, 3, 6] \cdot [2, 2, 1]^T = 24$

ReLU: $\max(0, 24) = 24$

Q2

Consider a 1D convolution of a vector of size 12 and a filter of size 4 with stride 3. Calculate the size of the convolution output with padding size 1 (per side).

Answer

Useful equation (P and S stand for padding and stride respectively):

$$N_{\text{out}} = \lfloor \frac{N_{\text{in}} + 2P - N_{\text{kernel}}}{S} \rfloor + 1$$

Therefore, the answer is

$$\lfloor \frac{12 + 2 \cdot 1 - 4}{3} \rfloor + 1 = 4$$

Q3

Consider a 1D convolution layer with input dimension 256, 10 filters of size 8 and stride 1, and no padding. Calculate the number of parameters. Assume that there is no bias.

Answer

There is one parameter for each entry in a filter, so the answer is

$$10 \cdot 8 = 80$$

Q4

Consider a convolution of an image of size 120×120 and a filter of size 31×31 and stride 1. How many pixels of padding per side are needed to obtain a result of size 120×120?

Answer

Plug in the numbers into the equation in **Q2**, we have

$$120 = \lfloor \frac{120 + 2P - 31}{1} \rfloor + 1$$

Solving it leads to the answer

$$P = 15$$

Q5

Consider a convolution of an image of size 50×50 and a filter of size 17×17 and stride 1. How many pixels of padding per side are needed to obtain a result of size 48×48?

Answer

Plug in the numbers into the equation in **Q2**, we have

$$48 = \lfloor \frac{50 + 2P - 17}{1} \rfloor + 1$$

Solving it leads to the answer

$$P = 7$$

Q6

Consider a convolution of an image of size 52×52 and a filter of size 5×5 and stride 2. What is the size of the output?

Answer

By the equation in **Q2**:

$$\lfloor \frac{52 + 0 - 5}{2} \rfloor + 1 = 24$$

Q7

Consider passing an image of size 1024×1024 to a max pooling layer with a kernel of size 2×2 with stride 1, and padding of 1 pixel per side. How many weights are there in this pooling layer?

Answer

0

Q8

Let $L^{(i)}$ be a pooling layer in a CNN, can the number of nodes in layer $L^{(i-1)}$ be less than the number of nodes in layer $L^{(i+1)}$? Briefly explain.

Answer

Generally no.

However, if padding is not included in the definition of layer nodes, then one can think of a degenerative case where meaningless paddings are added to create an output larger than the input.