University of Stuttgart | ANALYTIC COMPUTING

Foundations of Machine Learning - Exercise (SS 25)

Assignment 11: Neural Networks - Advanced Architectures

Arvindh Arunbabu
arvindh.arun@ki.uni-stuttgart.de

Nadeen Fathallah
Nadeen.Fathallah@ki.uni-stuttgart.de

Cosimo Gregucci
cosimo.gregucci@ki.uni-stuttgart.de

Akram Sadat Hosseini
Akram.Hosseini@ki.uni-stuttgart.de

Farane Jalali
farane.jalali-farahani@ki.uni-stuttgart.de

Osama Mohammed
osama.mohammed@ki.uni-stuttgart.de

Jiaxin Pan
jiaxin.pan@ki.uni-stuttgart.de

Tim Schneider
tim.schneider@ki.uni-stuttgart.de

Jingcheng Wu
jingcheng.wu@ki.uni-stuttgart.de

Daniel Frank
daniel.frank@ki.uni-stuttgart.de

Submit your theoretical solution in ILIAS as a single PDF file.[1] Make sure to list the full names of all participants, matriculation number, study program, and B.Sc. or M.Sc on the first page. Optionally, you can *additionally* upload source files (e.g., PPTX files). Submit your programming task in ILIAS as a single Jupyter notebook. If you have any questions, feel free to ask them in the exercise forum in ILIAS.

Submission is open until Monday, 14th of July, 12:00 noon.

[1] Your drawing software probably allows exporting as PDF. An alternative option is to use a PDF printer. If you create multiple PDF files, use a merging tool (like pdfarranger) to combine the PDFs into a single file.

Task 1: Convolutional Neural Networks

Consider the a 4×4 input X with one channel and a 3×3 filter F.

$$X = \begin{bmatrix} X_{00} & X_{01} & X_{02} & X_{03} \\ X_{10} & X_{11} & X_{12} & X_{13} \\ X_{20} & X_{21} & X_{22} & X_{23} \\ X_{30} & X_{31} & X_{32} & X_{33} \end{bmatrix}, \quad F = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ -1 & 0 & 0 \end{bmatrix}$$

1. **Task** Compute the output of applying convolution to X using F, with a stride of 1×1 and zero padding.
2. **Task** What shape would the output have for an input of size 64×128?
3. **Task** You are given an input image and four convolutional filters:

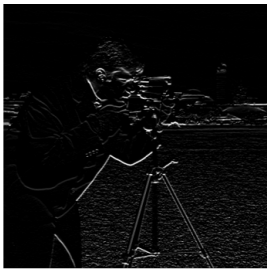
$$\text{F1} = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}, \quad \text{F2} = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}, \quad \text{F3} = \frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}, \quad \text{F4} = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Four output images (a), (b), (c) and (d) result from applying these filters to the input image using 2D convolution with stride 1×1 and zero padding.

a

b

c



d

Which image, (a), (b), (c) or (d), corresponds to the output of F1, F2, F3 and F4? Explain your reasoning.

Task 2: BONUS 3 VOTES - PyTorch

Follow the instructions in the `jupyter` notebook. You can earn **3 extra votes** by completing this bonus task. Please note: This task is not part of the main assignment and will not count towards the 100% score. However, any extra votes earned will be added to your total vote count.