HOMEWORK 3

16824 VISUAL LEARNING AND RECOGNITION (FALL 2023)
https://piazza.com/class/llo9w21ejlp2f

RELEASED: Wed, 25th Oct 2023
DUE: Wed, 20th Nov 2023
Instructor: Jun-Yan Zhu
TAs: Zhipeng Bao, Wen-Hsuan Chu, Yeojin Jung, Rutika Moharir

START HERE: Instructions

- **Collaboration policy:** All are encouraged to work together BUT you must do your own work (code and write up). If you work with someone, please include their name in your write-up and cite any code that has been discussed. If we find highly identical write-ups or code or lack of proper accreditation of collaborators, we will take action according to strict university policies. See the Academic Integrity Section detailed in the initial lecture for more information.
- **Late Submission Policy:** There are a **total of 10** late days across all homework submissions. Submissions that use additional late days will incur a 10% penalty per late day.
- **Submitting your work:**
  - We will be using Gradescope (`https://gradescope.com/`) to submit the Problem Sets. Please use the provided template only. Submissions must be written in LaTeX. All submissions not adhering to the template will not be graded and receive a zero.
  - **Deliverables:** Please submit all the `.py` files. Add all relevant plots and text answers in the boxes provided in this file. TO include plots you can simply modify the already provided latex code. Submit the compiled `.pdf` report as well.

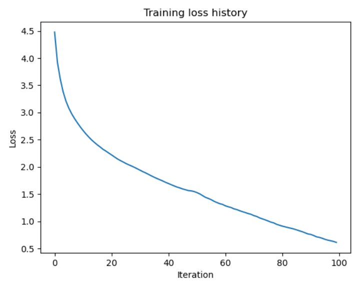
NOTE: Partial points will be given for implementing parts of the homework even if you don't get the mentioned numbers as long as you include partial results in this pdf.

1 Image Captioning with Transformers (70 points)

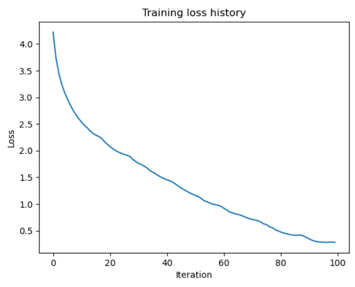
We will be implementing the different pieces of a Transformer decoder (Transformers), and train it for image captioning on a subset of the COCO dataset.

- **Setup:** Run the following command to extract COCO data, in the `transformer_captioning/datasets` folder : `./get_coco_captioning.sh`
- **Question:** Follow the instructions in the `README.md` file in the `transformer_captioning` folder to complete the implementation of the transformer decoder.
- **Deliverables:** After implementing all parts, use run.py for training the full model. The code will log plots to `plots`. Extract plots and paste them into the appropriate section below.
- **Expected results:** These are expected training losses after 100 epochs. Do not change the seed in run.py.
  - 2-heads, 2-layers, lr 1e-4: Final loss ≤ 1
  - 4-heads, 6-layers, lr 1e-4: Final loss ≤ 0.3
  - 4-heads, 6-layers, lr 1e-3: Final loss ≤ 0.05

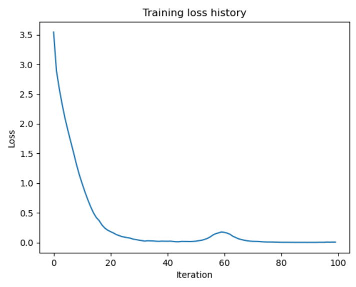
1. Paste training loss plots for each of the three hyper-param configs
   2-heads-2-layers-lr-1e-4: **TODO: fill in final train loss here.**
   4-heads-6-layers-lr-1e-4: **TODO: fill in final train loss here.**
   4-heads-6-layers-lr-1e-3: **TODO: fill in final train loss here.**



(a) 2-heads-2-layers-lre-4

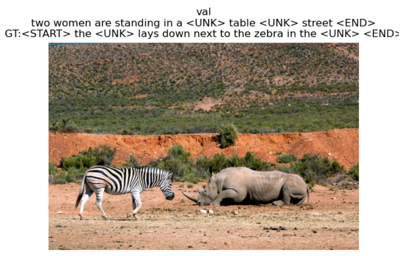


(b) 4-heads-6-layers-lre-4

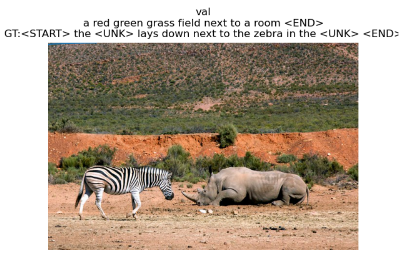


(c) 4-heads-6-layers-lre-3

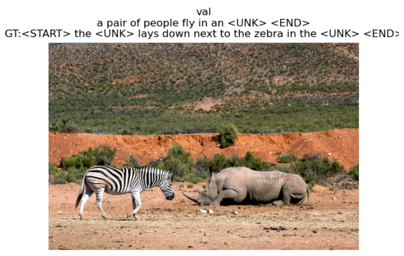
2. Paste any three generated captioning samples from the training set with the three different settings. The provided code creates these plots at the end of training.


val
two women are standing in a <UNK> table <UNK> street <END>
GT:<START> the <UNK> lays down next to the zebra in the <UNK> <END>

(a) Sample1: 2-heads-2-layers-lre-4


val
a red green grass field next to a room <END>
GT:<START> the <UNK> lays down next to the zebra in the <UNK> <END>

(b) Sample2:4-heads-6-layers-lre-4


val
a pair of people fly in an <UNK> <END>
GT:<START> the <UNK> lays down next to the zebra in the <UNK> <END>

(c) Sample3:4-heads-6-layers-lre-3

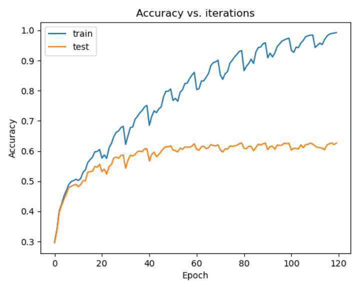
3. Based on the observations of the three different settings, What would you change in the training procedure to get better validation performance? Why tweaking these hyper-parameters will lead to better performances?

Solution:
I will reduce the learning rate while increasing the number of heads and layers. Reducing the learning rate stabilizes training, and increasing the number of heads and layers in a transformer boosts model capacity, potentially reducing loss, but the effectiveness depends on the specific task and dataset.

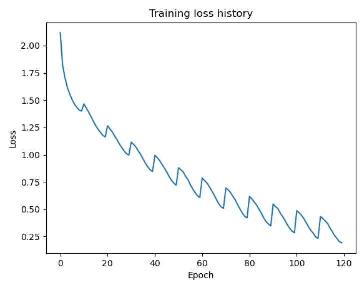
2 Classification with Vision Transformers (30 points)

We will use the transformer you implemented in the previous part to implement a Vision Transformer (ViT), for classification on CIFAR10.

- **Question:** Follow the instructions in the `README.md` file in the `vit_classification` folder. You are encouraged to resuse code from the previous question.
- **Deliverables:** Run training using `run.py` for training the full model. The code will log plots `acc_out.png` (train and test accuracy) and `loss_out.png` (train loss).
- **Expected Results:** After 100 epochs, test accuracy should be $\geq$ 65%, train accuracy should be $\approx$ 100%, and training loss $\leq$ 0.3.



(a) Train/test accuracy



(b) Training loss

Collaboration Survey Please answer the following:

1. Did you receive any help whatsoever from anyone in solving this assignment?
   - ◯ Yes
   - ◯ ✓No
   - If you answered 'Yes', give full details:
   - (e.g. "Jane Doe explained to me what is asked in Question 3.4")

2. Did you give any help whatsoever to anyone in solving this assignment?
   - ◯ Yes
   - ◯ ✓No
   - If you answered 'Yes', give full details:
   - (e.g. "I pointed Joe Smith to section 2.3 since he didn't know how to proceed with Question 2")

3. Note that copying code or writeup even from a collaborator or anywhere on the internet violates the Academic Integrity Code of Conduct.