CSE 398/498 - Assignment 4

Image Segmentation using U-Net

Logistics

The submission should be made on Course site in the form of a zip file named as **<your_full_name>_cv_24.zip** by **April 8, 2024 11:59pm (EST).**

Contents of the compressed folder should be organized in the following manner:

- **data/** - folder containing input images; your code should download the dataset in this folder if it doesn't exist
- **output/** - folder containing output or any helpful intermediary images, while you will generate a number of output masks, please only upload a subset when you submit (see task 3 and 4 for details)
- **src/** - containing your jupyter notebook, comment your code well
    - If you have never worked with jupyter, do not worry. The language of programming is Python which all of you are familiar with. The jupyter environment basically is an interactive coding environment, where you can edit and run your code from the browser. Code notebooks are generally like reports containing both code sections and text sections so you can run your code and write descriptions in the same file. Thus, you may not need a separate file for readme. The text sections in this file should contain all your answers and explanations as you would write in a report. More about Jupyter Notebooks: https://jupyter.org/try-jupyter/retro/notebooks/?path=notebooks/Intro.ipynb
- ~~**readme.md/readme.txt** - containing verbose description of the steps required to run your code and other observations/comments you may have for your submission. Treat this as a short report. Include any links you may have referred to in this document.~~
- **environment.yml** - exported conda environment file. Contains information about libraries and their versions. You can also just add the commands required to install the packages at the top of your jupyter notebook.

Credit: 5% of course total (Start this assignment early as processing will take time!!!) If you cannot run the sample script on your machine/laptop/Colab/Server, please contact the TA or grader ASAP.

Due date: April 8, 2024, 11:59 pm

Access to machine

This is the most computationally intensive assignment for the course, so, this may require special compute resources. You have 3 options -

- **Personal Desktop/Laptop -** If you have a personal computer with a GPU, you should be fine. If you have a personal computer with a relatively new CPU and decent number of cores (8), you should be able to finish the assignment but the process of training will be slow. It should still not take more than an hour to complete for 40 epochs.
- **Google Colab -** Colab allows anybody to write and execute arbitrary python code through the browser, and is especially well suited to machine learning, data analysis and education. More technically, Colab is a hosted Jupyter notebook service that requires no setup to use, while providing access free of charge to computing resources including GPUs. You will not need to set your own environment separately and you will just install them and import them inline. Out of the many times that I have tried to obtain resources (specially GPUs) on Colab, I have only been successful 40% of the time. Of late, they seem to be having more people and less GPUs. However, if you have an older laptop, getting CPU resources on Colab will also be useful. CPU resources are easy to obtain and you will always get them. This is a good guide with answers to a lot of questions you may have if you are using Colab for the first time: https://algotrading101.com/learn/google-colab-guide/
- **MAGIC server** - This is a server in Lehigh that hosts a JupyterHub. I have asked Todd to give you access for few weeks. You will login to this machine remotely. Access the jupyterhub from your local browser and complete the assignment. Now, this also has a limited number of GPUs, so if someone else is using them, you may not be able to get it. You will need to setup your conda environment here.

That said, the assignment can be done without GPUs, but you will generally need a good machine, so Colab/MAGIC might be the way to go (even if you don't get GPUs).

Pre-assignment

Prepare your laptop/MAGIC server environment. If you are trying to use Colab, just download the notebook provided with the assignment and open it with Colab. Virtual environments are a great way to ensure stability of your code execution and also improve its reproducibility. I suggest everyone to use the **Anaconda** package manager for your projects and assignments. If you have used it before, you already know. If you haven't used it before, it will make installations easier and project management better. Also, a lot of other people's code uses it so it's good to learn.

Quick tutorial for conda: https://conda.io/projects/conda/en/latest/user-guide/getting-started.html

By now, you all should be able to provide an environment that I can reproduce. Your assignment will not be evaluated if I cannot run it. Please contact me before submitting if you have any questions or issues.

We are going to need Python3 (any recent version should work) and a few libraries installed, in addition to the OpenCV library.

1. If you don't have Python3 and OpenCV, you can use your preferred way to install them, for instance install

Anaconda Python (https://www.anaconda.com/download/), and then use its package manager to install OpenCV:

```
$ pip install opencv-contrib-python
```

2. Now, all you need to do is to install `scikit-learn`, `pytorch(torchvision)` and `tqdm`. All of this will be inside your environment. This can be done with these commands:

If you are using pip:

```
$ pip install numpy scipy scikit-learn
$ pip install matplotlib
$ pip install imutils
$ pip install torch torchvision
$ pip install tqdm
```

3. Open the example code (the .ipynb file) and read instructions there. If you can't open it, reach out to me ASAP.

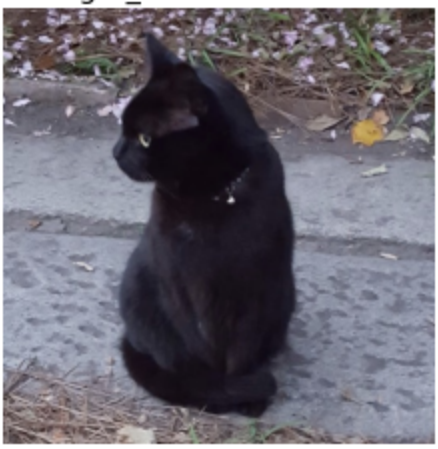
Trouble shooting:

To get your datasets in the environment, you might need to use scp command to copy data from local machine to MAGIC server. For use in Colab, you can upload the data to appropriate location in Google drive.

Task 1 (0 points):

- Run the pre-trained ResNet-50 on the black cat image and visualize the top 10 predictions. The code for this is provided. Your output should look like this:

Egyptian_cat: 0.33140698
American_black_bear: 0.109570384
tabby: 0.08524455
schipperke: 0.041931298
bucket: 0.023650177
groenendael: 0.021266444
Newfoundland: 0.020788986
wallaby: 0.019736601
kelpie: 0.017362222
tiger_cat: 0.01730053



-

Task 2 (0 points):

- Run matrix multiplication for a large matrix for CPU and GPU.
- Which configuration is the better (faster)? Why?

Task 3 (3 point, 1 for each bullet):

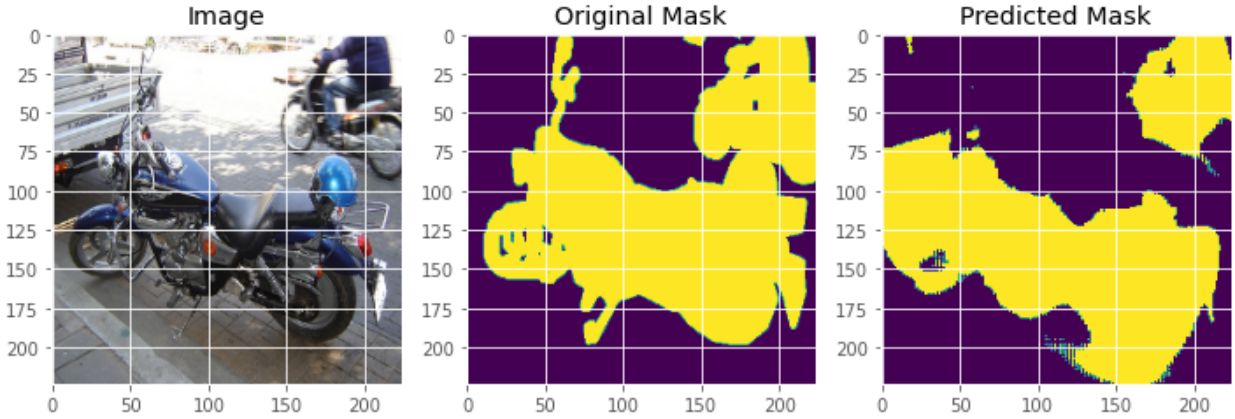
- Download the subset of PASCAL VOC dataset shared on Google drive. The train, val and test.txt files contain image ids that belong to each partition. You will use this in Section 5 of the code to create a list of file paths for each partition and then dataloaders (trainLoader and valLoader).
- You will record the average training (variable - avgTrainLoss) and validation loss (variable - avgValLoss) for each epoch in the dictionary H.
- Plot the loss vs. epoch curve for both training and validation towards the end of the training section. Add a title, axes labels and legend to your plot. Then, plot will be saved.

Upload the trained model and loss plot in the output folder of your submission.

Task 4 (2 point, 1 for each bullet):

- Evaluate the predictions from your trained model. Qualitative evaluation requires you to manually inspect similarity between ground truth and prediction. In code section 6, you will read test images and masks, pre-process them in the same way you transformed training images before feeding them into the network. The image preprocessing code has been provided. You need to write the reading and preprocessing code for ground

truth mask. You will then run the prediction and process the output mask to be visually inspected. Your visualization plots for each test instance should look like this.



You will run this for 10 random images and submit the visualization in your output folder.

- Finally, you will implement how to calculate IoU for mask comparisons and report the mean IoU for randomly selected 100 images from the test set. Submit the list of images selected as a text file and report the meanIoU over all the 100 in your report/notebook as text. Additionally, you will comment on how good or bad your model did qualitatively and quantitatively and provide reasons.

Deadline Extensions and Late Submissions:

- First deadline extension request will be granted with a 3-day extension automatically and you won't be penalized. ***Applicable to Assignments and Projects***
- For subsequent late submissions, you will lose 10% for each day late for the programming projects. This means anytime within the first 24 hours after the due date count as 1 full day, up to 48 hours is two and 72 for the third late day. Beyond that, your submission will not be graded. ***Applicable to only Assignments***

Please clarify this with the instructor if the policy is not clear before you submit late.

Statement on Academic Integrity

University -We, the Lehigh University Student Senate, as the standing representative body of all undergraduates, reaffirm the duty and obligation of students to meet and uphold the highest principles and values of personal, moral and ethical conduct. As partners in our educational community, both students and faculty share the responsibility for promoting and helping to ensure an environment of academic integrity. As such, each student is expected to complete all academic course work in accordance to the standards set forth by the faculty and in compliance with the University's Code of Conduct.

Course - The work you do in this course must be your own. This means that you must be aware when you are building on someone else's ideas—including the ideas of your classmates, your professor, and the authors you read—and explicitly acknowledge when you are doing so. Feel free to build on, react to, criticize, and analyze the ideas of others but, when you do, make it known whose ideas you are working with. If you ever have questions about drawing the line between others' work and your own, ask me and I will give you clear guidance or you may visit Lehigh Library's 'Proper Use of Information' page at http://libraryguides.lehigh.edu/plagiarism

Grade Specific - Zero assigned to the Quiz/Assignment for first offense and the student will Fail the class on second offense.

For assignments, you can discuss with peers but the code should be your own. For quizzes, no consultation with a living or non-living entity is allowed.

University COVID Policy:

To meet the challenge of teaching and learning during the COVID-19 pandemic, Lehigh instructors and students will be adopting new forms of instruction and interaction; following new guidelines around classroom behaviors; enhancing communications; and doing our best to be patient, flexible, and accommodating with each other. In remote synchronous meetings, students are expected to attend just as they would any other Lehigh class. Zoom classes work best when all students come to class ready to participate and follow the instructor's guidelines regarding use of web-cameras. You may be asked to turn your camera on during active learning sessions in Zoom. If you have a strong preference not to do so, please contact your instructor to let them know. Students should respect the in-classroom privacy of their instructors and fellow students by not taking screenshots or recording class sessions. Some instructors will record Zoom sessions; however, any recorded live sessions will be shared only with students in the class and will be deleted at the end of the semester.

In our physical classrooms, Lehigh has established a policy requiring everyone to wear face coverings when in public spaces inside buildings on our campus and to maintain social distance. This policy applies to our physical classroom. Thank you in advance for following this rule. Students who do not wear a face covering during in-class meetings will be reminded to put their face covering on. If they do not do so, they will be asked once again to do so or leave the classroom.