UMBC
CMSC 491/691 Computer Vision

Homework 4
491: 80 points (110 counting extra credit)
691: 100 points (110 counting extra credit)

Due: May 10, 2023 23:59 Eastern

Answer all problems according to the instructions provided.
Written problems may be typeset or handwritten.
Submit one `.zip` file named `LastName_FirstName_hw4.zip` containing a single `pdf` named `hw4.pdf` with the answers to both the written and coding sections. The pdf **must** contain relevant code snippets, outputs and results, and other requested information for each task. Put all other files (code, data, outputs, etc.) in a single directory named "`code`"

1 Training an Image Classifier (40)

In the in-class tutorial, the TA demonstrated how a fully-connected neural network can be implemented, trained, and tested for classifying garments from the FashionMNIST dataset. In this homework problem, please refer to this PyTorch documentation https://pytorch.org/tutorials/beginner/blitz/cifar10_tutorial.html#sphx-glr-beginner-blitz-cifar10-tutorial-py and implement and train a convolutional neural network to classify CIFAR-10 images.

Task 1 *Results Reproduction* 5 points
Show that by following the tutorial carefully, you can reproduce the results demonstrated in the tutorial. Show snapshots of your test accuracy in your terminal / notebook / colab.

Task 2 *Failure Cases* 5 points
Identify 5 cases where the model predicted the wrong output. Display these images, the true label, and the predicted label.

Task 3 *Hyperparameter Tuning* 15 points

A Try various values for hyperparameters such as learning rate, batch size, number of epochs, etc. List at least one hyperparameters (besides the three mentioned above) that you decided to tune.

B Report your experimental results in a table similar to the one below, with as many rows as the combinations that you tried. The first three columns should show the hyperparameter values and the last column should show the test accuracy in percentage In the final row, report your the combination of hyperparameter values that resulted in the **best (highest)** accuracy.

Epochs	Batch Size	Learning rate	Test Accuracy
2	4	0.001	54.00
...	...	...	...

Task 4 *Dataset augmentation* 15 points

One technique to improve the accuracy of your classifier is to show more diverse data through dataset augmentation. Implement dataset augmentation with rotations, translations, flipping. Show some examples of the augmented training data, and then report the performance of this technique.

A Describe the augmentations and their magnitudes (eg. rotation by X degrees) and combinations of augmentations that you used. (3)

B How much did performance improve? (5)

C Why do you think the above data augmentation techniques helps in improving accuracy? (4)

D What other image operations do you think could be good data augmentations? Why? (3)

Task 5. (Extra Credit) Robustness (10 points)

In the above coding assignment on training an image classifier, we trained a CNN f to classify images into one of the 10 CIFAR classes. After training, I decided to do something weird: I used an MNIST (handwritten digit) image to test this classifier.

1. What would the classifier's prediction be? Remember that the prediction is defined as the argmax over softmax probabilities.
2. Comment on the confidence (probability) of the prediction of for an "unseen class" (eg. the digit 7 or a human face) vs. the confidence for a "seen class" (found in the CIFAR-10 dataset).
3. According to you, what algorithmic safeguards can be placed on computer vision models so that such unseen data does not cause failures?

2 Evaluation of Object Detection Models (40)

The goal of the assignment is to use several different object detection models to detect objects in images and then evaluate and compare the performance of these models by implementing different evaluation metrics.

The following notebook contains instructions and code blocks to implement your solutions: https://colab.research.google.com/drive/11OVrERQq2LDnlxffy9ODKnSKZKv3YKxi?usp=sharing. Make a copy of this notebook and submit the entire notebook in the code directory of your submission. Include relevant code snippets and outputs in your pdf when responding to the following tasks:

Task 1. *Load Object Detector Models* 5 points

Use pretrained models from PyTorch and set them in eval mode. Note: choose `fasterrcnn_resnet50fpn` and three other models and name them `model0, model1, model2, model3`.

Task 2. *Object Detection Pipeline* 15 points

Write a Python function that takes an image, model variable, and confidence threshold as input, and returns a list of predicted boxes and a list of predicted classes.

Task 3. *Display Detections* 5 points

Now use Matplotlib to write a function that takes an image path as input, uses `get_detection` to obtain a list of boxes and classes, and displays the detections. This code must display the image, overlay the bounding boxes and predicted classes on top of the image.

Task 4. *Evaluation using MS-COCO dataset.* 15 points
We will use MS-COCO (https://cocodataset.org/). The notebook walks you through downloading and loading images and annotations from the COCO dataset. You do not need to edit this part. Using the dataloader, load the first 100 images from COCO. Write code that takes the ground-truth bbox and class_id from the dataloader, compared it with the predictions, and returns IoU score (intersection over union) that we discussed in class. You should write it as a separate function `eval_iou()` and call it inside the loop.

- Calculate the meanIOU over the entire dataset of 100 images.
- Report the meanIOU for all 4 models in a table.
- Similarly, report the precision and recall of each model.

3 Required for 691. (Extra Credit for 491) Guest Lectures (20)

For any two guest lectures of your choice, follow the prompts below and submit your responses:

1. Summarize the talk in a couple of paragraphs. You can write about the big-picture topic of the talk and specific projects (tasks, methods, results, etc.) *(4 points)*
2. **Questions/Discussions:** If you asked a question, please summarize that question and the answer from the speaker. If you didnt ask a question, please summarize any question that was asked and the answer from the speaker. *(3 points)*
3. **What was your favorite part of the talk / discussion?** *(2 points)*
4. Cite one of the speaker's published paper that they discussed in detail during the talk. *(1 points)*