Advanced Deep Learning 2024 Assignment 4

This is an **individual assignment** and its deadline is **Tuesday, June 14, 2024, 22:00**. You must submit your solution electronically via the Absalon home page.

Important: Please include your code with the submission!

Page Limit: Max. 5 pages

1 Segment Anything

In this assignment, you will experiment with using the Segment Anything Model (SAM) [1] on the x-ray dataset for lung segmentation that you are already familiar with from Assignment 1. Your goal is to check whether the claim of the ability to segment "anything" also extends to medical x-ray images. Start by reading the "Segment Anything" paper and get familiar with how the model was trained and how it was evaluated. Your task is to:

1. Briefly discuss: Based on the training of the model and the evaluation results presented in the paper, do you expect SAM to perform well on medical x-ray segmentation tasks?

2. Experiment with SAM using the interactive web interface on `https://segment-anything.com/demo`[1]. Use the three attached lung x-ray images and try to interactively segment the lungs using point, bounding box and automatic mode. Briefly analyze these preliminary results qualitatively and discuss the pro's and con's of each prompting method, as well as the general suitability of SAM for the given task.

2 Prompt Engineering in Python

Take a look at this example notebook on how to use SAM with prompts: `https://github.com/facebookresearch/segment-anything/blob/main/notebooks/predictor_example.ipynb`. To get started with SAM on the lung x-ray dataset, the jupyter notebook `sam_lung_xrays.ipynb` is provided in the assignment resources. Your task is to:

3. Implement the missing parts for loading and transforming the data for the SAM `predictor` object (indicated by `TODO` comments). Pick an appropriate prompt to segment the lungs in the single example image[2]. Visualize your approach by showing the example image overlaid by an illustration of your prompt (i.e. points or bounding boxes) and the resulting segmentation mask.

[1] If you have issues with the web interface, try running it on Google Chrome.
[2] Hint: Consult the example notebook for possible prompting inputs.

Figure 1: Bounding box annotations generated from the ground-truth lung segmentation masks.

4. Evaluate your prompting method by using SAM to segment the lungs on the validation split of the dataset. Report the average and standard deviation of the F1-score. Briefly analyze the results qualitatively on two selected example images.

3 Dynamic Prompting

Using an object detection model to detect the bounding boxes of the lungs is a more flexible way to prompt SAM. You can first try out the potential of this method by using the ground-truth masks to generate bounding boxes. Afterwards, you should train an object detection model on these ground-truth bounding boxes to be able to dynamically prompt SAM to detect lungs in x-ray images.

5. Generate two bounding boxes for each image from the ground-truth lung segmentation masks for the train, val and test splits, as illustrated in Figure 3. Briefly describe your approach.

6. Prompt SAM with the bounding boxes and compare your results on the F1 Score to your previous prompting method. You may use additional inputs for optimizing your prompt.

7. Using any tools or libraries, implement an object detection model of your choice and train it to detect the lungs based on your generated ground-truth bounding boxes. Report on the Intersection over Union performance of the object detection model on the test set. Prompt SAM with the predicted bounding boxes and evaluate the performance on the test split using the F1-score. Discuss the efficacy of this approach and compare it to your previous prompting method and to the U-Net from Assignment 1.

References

[1] Alexander Kirillov, Eric Mintun, Nikhila Ravi, Hanzi Mao, Chloe Rolland, Laura Gustafson, Tete Xiao, Spencer Whitehead, Alexander C Berg, Wan-Yen Lo, et al. Segment anything. *arXiv preprint arXiv:2304.02643*, 2023.