

COMP0197 CW2

This file contains instruction for executing code for COMP0197 Applied Deep Learning coursework 2.

Setting up Environment

Prerequisites

- Python: Version 3.x recommended.
- pip: Python package installer.
- Git: For cloning the repository (if not already downloaded).
- (Optional): CUDA-enabled GPU for significantly faster training and evaluation.

Base Environment

To create a base conda environment, please execute the below script.

```
conda create -n comp0197-cw2-pt python=3.12 pip && conda activate comp0197-cw2-pt
&& pip install torch==2.5.0 torchvision --index-url
https://download.pytorch.org/whl/cpu
```

Extra Dependencies

In addition to above base packages, this codebase also requires below packages to be installed.

```
pip install scikit-image torchmetrics
```

Script Execution Instructions

Fully Supervised Model

Fully supervised models are trained to provide comparison with weakly supervised models. To train a fully supervised segmentation model:

```
python -m supervised.train --model=segnet
```

If you're using a MacBook with an M1, M2, or M3 chip, we suggest enabling CPU fallback for better compatibility:

```
PYTORCH_ENABLE_MPS_FALLBACK=1 python -m supervised.train --model=segnet
```

Available segmentation model options are: [segnet, segnext, effunet, unet]

Weakly Supervised Model

NOTE: Below command are designed to be executed in sequence. Breaking the sequence or exiting training scripts early may result in receiving errors due to saved model weights not found.

Finetune classifier

Run without regularisation: `python -m cam.finetune`

If skipping training is desired, please download saved models from below link and place it under `./cam/saved_models/`: [resnet_pet_cam.pth](#)

Run with regularisation:

- `python -m crm.train_cam_with_crm`
- `python -m crm.evaluate_with_crm`

If Mac users ran into segmentation fault, please download saved models on OneDrive and place them under `./crm_models/`

- **Resnet:**
<https://1drv.ms/u/c/2ef0e412637ecc3c/EawGxav3g3BPke8uXA7C5W0Bdf2oIHQSoV6smZgRWXR1NA>
- **Reconstruction network:**
https://1drv.ms/u/c/2ef0e412637ecc3c/EdhrCblkW6dEpXfImbAcRsoBBb_3ceJHz16NxfTiQLPmHg?e=llvOmN
- **Resnet DRS:** <https://1drv.ms/u/c/2ef0e412637ecc3c/EQU-6ec3hklKHi9hTXwXxDEBWx5czmOywqLiH3gsT0qhAQ?e=nkVYuQ>.
- **Reconstruction network Drs:**
<https://1drv.ms/u/c/2ef0e412637ecc3c/EesRuHMqygZAvj6Qc710poYBfyskimMUQtJAFrfC9wmOCw?e=YEFLuq>

NOTE: `crm.train_cam_with_crm` will generate superpixels under directory `./superpixels`. To skip the generation, simply download from OneDrive and unzip it under project root. If training was killed early, rerunning could lead to into `superpixels/xxx not found error`, please try to remove the `./superpixels` folder and rerun, or download and zip from OneDrive.

- Superpixels:
<https://1drv.ms/u/c/2ef0e412637ecc3c/EQy9SXX7x4tGnqJWRpIJJa7EBYK9I7c2ipQB07oCzcjAfKQ?e=Ovlgq5>

All available command argument for `train_cam_with_crm`:

- **model:** Classification model name, allowed value ['resnet', 'resnet_drs']
- **cls_lr:** Classifier learning rate
- **rec_lr:** Reconstruction net learning rate
- **vgg_weight:** Weight for VGG loss
- **align_weight:** Weight for alignment loss
- **epochs:** Number of training iteration

All available command argument for `evaluate_with_crm`:

- **model:** Classification model name, allowed value ['resnet', 'resnet_drs']

Get pseudo masks generated

Users can specify which model to use to indicate whether the run is with or without regularisation. Please note that this choice needs to align with the previous step **Finetune Classifier**. That is, if the previous step is run with regularisation, this step needs to run with regularisation too.

Run without regularisation: `python -m cam.postprocessing --model=resnet`

If the generation is taking too long, please download the saved pseudo mask from below link and place it under `./cam/saved_models/`: [resnet_pet_cam_pseudo.pt](#)

Run with regularisation: `python -m cam.postprocessing --model=resnet_crm`

All available command argument for **postprocessing**:

- **model**: Classification model name, allowed value ['resnet', 'resnet_crm', 'resnet_drs']

Sample heatmap images are generated in the `cam/output/cam_grid.jpg`

Train the SegNet segmentation model with pseudo masks

If classifier used in previous steps is simple resnet, model and pseudo masks are save in `cam/saved_models` folder:

```
python -m supervised.train --model=segnet --pseudo --  
pseudo_path=cam/saved_models/resnet_pet_cam_pseudo.pt
```

If classifier used earlier is with regularisation, i.e. `resnet_crm` or `resnet_drs`, model and pseudo masks are save in `crm_models/` folder:

```
python -m supervised.train --model=segnet --pseudo --  
pseudo_path=cam/saved_models/resnet_pet_gradcampp_crm_pseudo.pt
```

All available command arguments for **train**:

- **model**: Segmentation model name, allowed value ['segnet', 'segnext', 'effunet', 'unet']
- **pseudo**: boolean, whether to use pseudo mask
- **pseudo_path**: path where pseudo mask is saved
- **verbose**: boolean, whether to print verbose message

Ablation Experiments

Ensure the classification model is saved under `cam/saved_models` prior to running below code.

To perform grid search: `python -m ablation.grid_search`

All available command arguments for **grid_search**:

- **model**: Segmentation model name, allowed value ['segnet', 'segnext', 'effunet', 'unet']
- **model_path**: Path where trained classifier model is saved
- **result_path**: Path to search results.

Open-ended Section

This section details the steps to download data, prepare labels (if needed), train models with different supervision strategies, and evaluate them.

Step 1: Download Data

This script checks if the Oxford-IIIT Pet Dataset has been downloaded already. If not, download it.

```
python -m open_ended.download_data
```

Note: This command will download the dataset into a directory (likely `./data` based on subsequent commands). Ensure you have sufficient disk space and an internet connection.

Step 2: Generate Weak Labels (Optional, Attached in submission)

This script generates the sparse weak annotations (points, scribbles, boxes) from the ground-truth segmentation masks provided by the original dataset.

```
python -m open_ended.weak_label_generator --data_dir ./data/oxford-iiit-pet --  
output_file ./open_ended/weak_labels/weak_labels_train.pkl
```

- **data_dir** ./data/oxford-iiit-pet: Specifies the directory where the Oxford-IIIT Pet dataset was downloaded (input).
- **output_file** ./open_ended/weak_labels/weak_labels_train.pkl: Specifies the path to save the generated weak labels as a Python pickle file (output).

Important Note: Pre-generated weak labels (*weak_labels_train.pkl*) are already included in the *./open_ended/weak_labels/* directory within the repository. Therefore, running this step is generally NOT necessary unless you want to regenerate the labels with different parameters or settings.

Step 3: Train Segmentation Models

This is the core step where the segmentation model is trained using different weak supervision configurations. The script *open_ended/train.py* is used repeatedly with different arguments.

Common Training Arguments:

- **supervision_mode** [mode]: ****Crucial argument.**** Specifies the type of weak supervision to use. Examples below use `points`, `scribbles`, `boxes`, and various `hybrid_...` combinations.
- **run_name** [name]: A unique name for this specific training run. Used for logging and naming checkpoint files (e.g., `segnet_points_run1`).
- **data_dir** ./data/oxford-iiit-pet: Path to the dataset directory.
- **weak_label_path** ./open_ended/weak_labels/weak_labels_train.pkl: Path to the file containing the weak labels.
- **batch_size** 64: Number of samples per batch during training. Adjust based on GPU memory.
- **lr** 2e-4: Learning rate for the optimizer.
- **epochs** 25: Number of training epochs.
- **num_workers** 8: Number of worker processes for data loading. Adjust based on your system's CPU cores.
- **img_size** 256: Resize input images to this square dimension.
- **checkpoint_dir** [path]: Directory where model checkpoints (saved model weights) will be stored.

Training with Single Weak Supervision Types:

These commands train separate models, each using only one type of weak annotation. Checkpoints are saved in ***./checkpoints_single***.

Points:

```
python -m open_ended.train \  
    --supervision_mode points \  
    --run_name segnet_points_run1 \  
    --data_dir ./data/oxford-iiit-pet \  
    --weak_label_path ./open_ended/weak_labels/weak_labels_train.pkl \  
    --batch_size 64 \  
    --lr 2e-4 \  
    --epochs 25 \  
    --num_workers 8 \  
    --img_size 256 \  
    --checkpoint_dir ./checkpoints_single
```

Scribbles:

```
python -m open_ended.train \  
    --supervision_mode scribbles \  
    --run_name segnet_scribbles_run1 \  
    --data_dir ./data/oxford-iiit-pet \  
    --weak_label_path ./open_ended/weak_labels/weak_labels_train.pkl \  
    --batch_size 64 \  
    --lr 2e-4 \  
    --epochs 25 \  
    --num_workers 8 \  
    --img_size 256 \  
    --checkpoint_dir ./checkpoints_single
```

Bounding Boxes:

```
python -m open_ended.train \  
    --supervision_mode boxes \  
    --run_name segnet_boxes_run1 \  
    --data_dir ./data/oxford-iiit-pet \  
    --weak_label_path ./open_ended/weak_labels/weak_labels_train.pkl \  
    --batch_size 64 \  
    --lr 2e-4 \  
    --epochs 25 \  
    --num_workers 8 \  
    --img_size 256 \  
    --checkpoint_dir ./checkpoints_single
```

Training with Hybrid Weak Supervision Types:

These commands train models using combinations of weak annotation types. Checkpoints are saved in ***./checkpoints_hybrid***.

Points + Scribbles:

```
python -m open_ended.train \  
    --supervision_mode points_scribbles \  
    --run_name segnet_points_scribbles_run1 \  
    --data_dir ./data/oxford-iiit-pet \  
    --weak_label_path ./open_ended/weak_labels/weak_labels_train.pkl \  
    --batch_size 64 \  
    --lr 2e-4 \  
    --epochs 25 \  
    --num_workers 8 \  
    --img_size 256 \  
    --checkpoint_dir ./checkpoints_hybrid
```

```
--supervision_mode hybrid_points_scribbles \  
--run_name segnet_hybrid_points_scribbles_run1 \  
--data_dir ./data/oxford-iiit-pet \  
--weak_label_path ./open_ended/weak_labels/weak_labels_train.pkl \  
--batch_size 64 \  
--lr 2e-4 \  
--epochs 25 \  
--num_workers 8 \  
--img_size 256 \  
--checkpoint_dir ./checkpoints_hybrid
```

Points + Boxes:

```
python -m open_ended.train \  
--supervision_mode hybrid_points_boxes \  
--run_name segnet_hybrid_points_boxes_run1 \  
--data_dir ./data/oxford-iiit-pet \  
--weak_label_path ./open_ended/weak_labels/weak_labels_train.pkl \  
--batch_size 64 \  
--lr 2e-4 \  
--epochs 25 \  
--num_workers 8 \  
--img_size 256 \  
--checkpoint_dir ./checkpoints_hybrid
```

Scribbles + Boxes:

```
python -m open_ended.train \  
--supervision_mode hybrid_scribbles_boxes \  
--run_name segnet_hybrid_scribbles_boxes_run1 \  
--data_dir ./data/oxford-iiit-pet \  
--weak_label_path ./open_ended/weak_labels/weak_labels_train.pkl \  
--batch_size 64 \  
--lr 2e-4 \  
--epochs 25 \  
--num_workers 8 \  
--img_size 256 \  
--checkpoint_dir ./checkpoints_hybrid
```

Points + Scribbles + Boxes:

```
python -m open_ended.train \  
--supervision_mode hybrid_points_scribbles_boxes \  
--run_name segnet_hybrid_points_scribbles_boxes_run1 \  
--data_dir ./data/oxford-iiit-pet \  
--weak_label_path ./open_ended/weak_labels/weak_labels_train.pkl \  
--batch_size 64 \  
--lr 2e-4 \  
--epochs 25 \  
--num_workers 8 \  
--img_size 256 \  
--checkpoint_dir ./checkpoints_hybrid
```

Step 4: Evaluate Trained Models

After training, use the ***open_ended/evaluate.py*** script to evaluate the performance of the saved model checkpoints on the test set.

```
python -m open_ended.evaluate \
  --data_dir ./data/oxford-iiit-pet \
  --model_paths
    checkpoints_single/segnet_boxes_run1_best_acc.pth \
    checkpoints_single/segnet_points_run1_best_acc.pth \
    checkpoints_single/segnet_scribbles_run1_best_acc.pth \
    checkpoints_hybrid/segnet_hybrid_points_boxes_run1_best_acc.pth \
    checkpoints_hybrid/segnet_hybrid_points_scribbles_boxes_run1_best_acc.pth \
    checkpoints_hybrid/segnet_hybrid_points_scribbles_run1_best_acc.pth \
    checkpoints_hybrid/segnet_hybrid_scribbles_boxes_run1_best_acc.pth \
  --batch_size 8 \
  --device cuda
```

Evaluation Arguments:

- **data_dir** ./data/oxford-iiit-pet: Path to the dataset directory.
- **model_paths** [path1] [path2] ...: ****Important:**** List the paths to the specific checkpoint files (`.pth`) you want to evaluate. These should typically be the checkpoints saved based on the best validation performance during training (e.g., `_best_acc.pth` or similar, as indicated by the filenames). Ensure these paths correctly point to the files generated in Step 4.
- **batch_size** 8: Batch size for evaluation. Can often be larger than training batch size depending on GPU memory.
- **device** cuda: Specifies the device for evaluation. Use `cuda` for GPU or `cpu` for CPU.

Note: The second `evaluate.py` command listed in the original README under a separate "Evaluate" heading seems potentially inconsistent or refers to different models/runs not shown in the main training sequence. This rewritten guide focuses on evaluating the models trained in Step 4 above.