CLIP Finetune in XTUNE

1. Data Prepare

1.1 Caltech101 Dataset

Xtune support some public dataset. You can refer to https://github.com/jilongW/GenAIComps/blob/main/comps/finetuning/src/integrations/xtune/doc/Prepare_dataset.md for details. Here we use Caltech101 dataset as an example, you can also create and use your own dataset.

If you want to use custom to finetune clip. Please register custom dataset to xtune. Please follow appendix a

1.1.1 Donwload Caltech101 dataset

- Create a folder named `caltech-101/` under `$DATA`.
- Download `101_ObjectCategories.tar.gz` from http://www.vision.caltech.edu/Image_Datasets/Caltech101/101_ObjectCategories.tar.gz and extract the file under `$DATA/caltech-101`.
- Download `split_zhou_Caltech101.json` from this link and put it under `$DATA/caltech-101`.

The directory structure should look like

```
$DATA/
|-- caltech-101/
|   |-- 101_ObjectCategories/
|   | split_zhou_Caltech101.json
```

The split_zhou_Caltech101.json contains how to partition the dataset.

1.1 Regist Caltech101 dataset to llama-factory

make `caltech101.json` in your dataset directory

```
[]
```

then make `dataset_info.json` in your dataset directory

```
{
  "caltech101": {
    "file_name": "caltech101.json"
  }
}
```

The directory structure should look like

```
$DATA/
|-- caltech-101/
|   |-- 101_ObjectCategories/
|   | split_zhou_Caltech101.json
|-- dataset_info.json
|-- caltech101.json
```

2. Install XTUNE

2.1 Install Driver for Arc A770

Please follow https://dgpu-docs.intel.com/driver/installation-rolling.html#ubuntu to install Driver. You can use clinfo -l to check whether driver is installed.

```
$ clinfo -l
Platform #0: Intel(R) OpenCL Graphics
 +-- Device #0: Intel(R) Arc(TM) A770 Graphics
```

2.2 Install XTUNE on native env.

Run install_xtune.sh to prepare component.

```
conda create -n xtune python=3.10 -y
conda activate xtune
git clone https://github.com/opea-project/GenAIComps.git
cd GenAIComps/comps/finetuning/src/integrations/xtune
apt install -y rsync
# open webui as default
bash prepare_xtune.sh
# this way it will not open webui
# bash prepare_xtune.sh false
```

You can see below info when you finished installation.

```
start llamafactory webui
server start successfully
```

You can run bash `prepare_xtune.sh false` to shutdown UI server. And use `bash prepare_xtune.sh` to start UI server again.

2.3 Install xtune on docker

2.3.1 Download Docker Image

You can use upstream docker image. Follow https://hub.docker.com/r/opea/finetuning-xtune

```
docker pull opea/finetuning-xtune
```

Or build docker image with below command:

```
cd ../../../deployment/docker_compose
export DATA="where to find dataset"
docker build -t opea/finetuning-xtune:latest --build-arg
https_proxy=$https_proxy --build-arg http_proxy=$http_proxy --build-arg
HF_TOKEN=$HF_TOKEN --build-arg DATA=$DATA -f
comps/finetuning/src/Dockerfile.xtune .
```

2.3.2 Run Docker with CLI

Suse docker compose with below command:

```
export HF_TOKEN=${your_huggingface_token}
export DATA="where to find dataset"
cd ../../../deployment/docker_compose
docker compose -f compose.yaml up finetuning-xtune -d
docker exec -it finetuning-xtune bash
apt install -y vim
vim run.sh
# change the run.sh to below
  PKGPATH=/usr/local/lib/python3.10/site-packages
  export
LD_LIBRARY_PATH=$PKGPATH/oneccl_bindings_for_pytorch/opt/mpi/lib/:$LD_LIBRA
RY_PATH
  source $PKGPATH/oneccl_bindings_for_pytorch/env/setvars.sh
  export FINETUNING_COMPONENT_NAME="XTUNE_FINETUNING"
  ray start --head --dashboard-host=0.0.0.0
  export RAY_ADDRESS=http://localhost:8265
  #python opea_finetuning_microservice.py
  export DATA=$DATA
  ZE_AFFINITY_MASK=0 llamafactory-cli webui
# change done
pip install -r integrations/xtune/requirements.txt
pip install "transformers<=4.49.0" optimum "auto_gptq>=0.5.0"
exit
docker restart finetuning-xtune
```

3. CLIP Finetune Method and Their Configurations

3.1 The core features for clip finetune tool:

Below method can run on Classification task and Image to Text task

Method	Detail Description
Full Finetune	**Enable Angle-Based Selection(base on the weight angle to determine which layer to update)**
Partial Finetuning - bias	**Allow users to customize which layers participate in training and which ones do not**
Prompt Tuning	**adding prompt embedding layer at the head of model or at the inputs of every layer and only train these layers**
Adapter Tuning	**adding adapter network at the end of encoder and only train this network**
Training free - Tip Adapter	**1. finetune CLIP model without any training or with few epochs learning 2. Added fixed cache size to reduce memory and enable experience sharing across different datasets**

3.2 Config features for clip finetune tool in command line: {id=3_2}

3.2.1 Basic yaml for vit_b16.yaml

see this in src/llamafactory/clip_finetune/configs/clip_finetune/vit_b16.yaml

```
DATALOADER:
  TRAIN_X:
    BATCH_SIZE: 32              # Train batch size
  TEST:
    BATCH_SIZE: 100             # Test batch size
  NUM_WORKERS: 4

INPUT:
  SIZE: (224, 224)              # resize image to this size
  INTERPOLATION: "bicubic"
  PIXEL_MEAN: [0.48145466, 0.4578275, 0.40821073]
  PIXEL_STD: [0.26862954, 0.26130258, 0.27577711]
  TRANSFORMS: ["random_resized_crop", "random_flip", "normalize"]

OPTIM:
  NAME: "sgd"
  LR: 0.02
  MAX_EPOCH: 50
  LR_SCHEDULER: "cosine"
  WARMUP_EPOCH: 1
  WARMUP_TYPE: "constant"
  WARMUP_CONS_LR: 1e-5

TRAIN:
  PRINT_FREQ: 1             # print acc after $PRINT_FREQ iteration
```

```yaml
MODEL:
  BACKBONE:
    NAME: "ViT-B/16"
```

3.2.2 Angle-Based Selection for full-finetune

Add below line in src/llamafactory/clip_finetune/configs/clip_finetune/vit_b16.yaml

```yaml
MODEL:
  ABS: True
  ABS_TOP: True                     # True: select top ABS_KEEP layer False: select bottom ABS_KEEP layer
  ABS_GROUP: True                   # True: select top ABS_KEEP layer in each group False: select bottom ABS_KEEP layer
  ABS_GROUP_NAME: ["k_proj", "v_proj", "q_proj"]    # How to divide layer into GTOUP, this means divide layers into 4 group. Each layer has k_proj in its name will into group 0, v_proj into group1, q_proj into group 2, other into group 3
  ABS_KEEP: 5                       # keep layer number
  BACKBONE:
    NAME: "ViT-B/16"
```

3.2.3 customize trained layer for partial-finetune

Add below line in src/llamafactory/clip_finetune/configs/clip_finetune/vit_b16.yaml

```yaml
MODEL:
  BACKBONE:
    NAME: "ViT-B/16"
BIAS:
  BIAS_TERMS: ["layer_norm", "layernorm"]   # which layer you want to train
  BIAS_TERMS_EXCLUDE: ["layernorm"]         # which layer you don't want to train
```

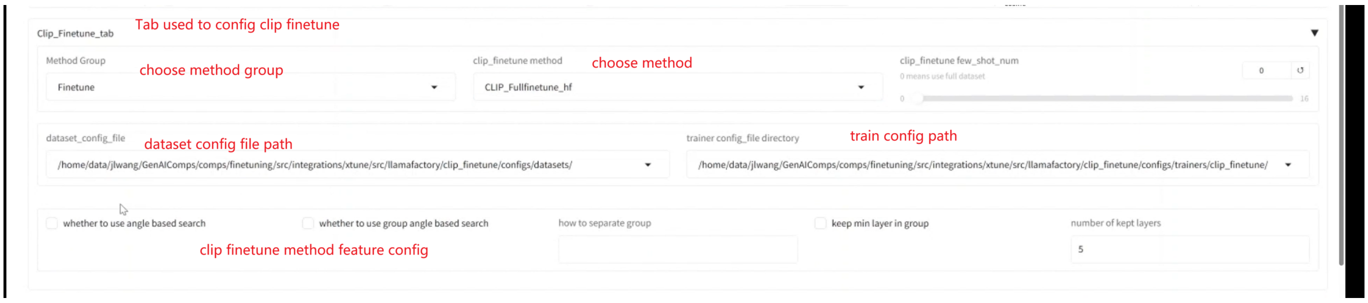
3.2.4 fixed cache size for tip-adapter

Add below line in src/llamafactory/clip_finetune/configs/clip_finetune/vit_b16.yaml

```yaml
TRAINER:
  TIP:
    LOAD_CACHE: True                    # whether to use cache data trained with tip-adapter before
    beta: 1.0                           # hyper param in origin paper
    alpha: 3.0                          # hyper param in origin paper
    AUGMENT_EPOCH: 10                   # train cache epoch
    search_best: True                   # whether to search the best beta
```

```
and alpha
    NEW: False                          # whether to use fixed cache size.
True: all dataset cache will merge into one tensor [100, hidden_size]
False: each dataset will has it's own cache [num_dataset * 100,
hidden_size]
    NEW_DATASET: False                  # Whether to train this dataset
from scratch
```

3.3 Config features for clip finetune tool in UI:


Clip_Finetune_tab — Tab used to config clip finetune

Method Group: Finetune — choose method group

clip_finetune method: CLIP_Fullfinetune_hf — choose method

clip_finetune few_shot_num: 0 (0 means use full dataset)

dataset_config_file: /home/data/jlwang/GenAIComps/comps/finetuning/src/integrations/xtune/src/llamafactory/clip_finetune/configs/datasets/ — dataset config file path

trainer config_file directory: /home/data/jlwang/GenAIComps/comps/finetuning/src/integrations/xtune/src/llamafactory/clip_finetune/configs/trainers/clip_finetune/ — train config path

☐ whether to use angle based search

☐ whether to use group angle based search

how to separate group:

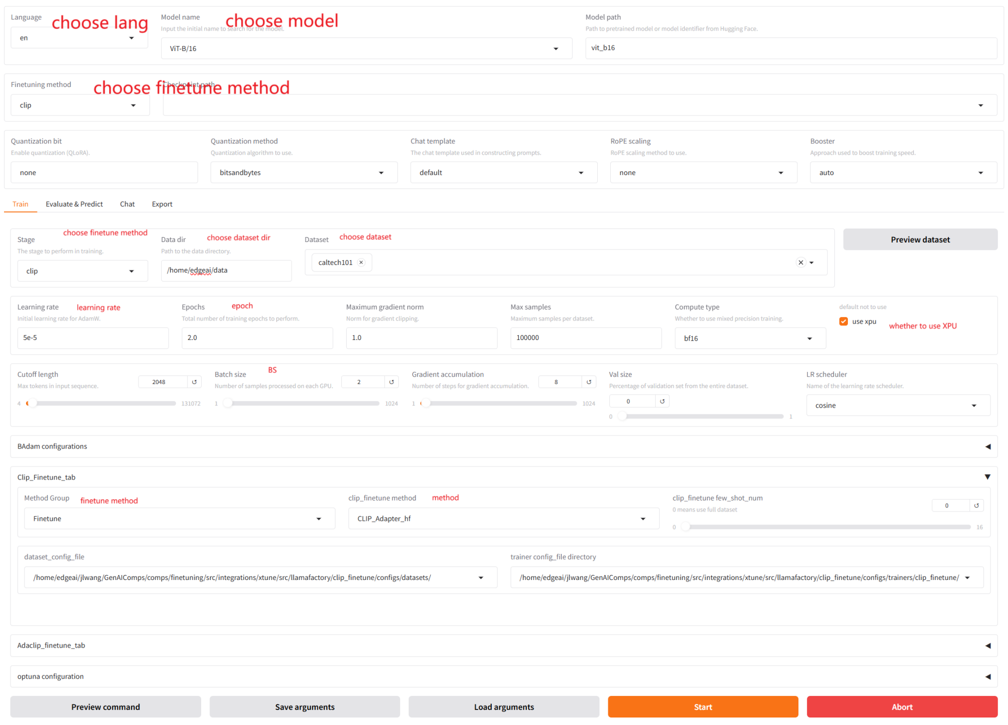
☐ keep min layer in group

number of kept layers: 5

clip finetune method feature config

4. Finetune Clip with GUI

4.1 How to finetune


Language: en — choose lang

Model name: ViT-B/16 — choose model

Model path: vit_b16

Finetuning method: clip — choose finetune method

Checkpoint path:

Quantization bit: none

Quantization method: bitsandbytes

Chat template: default

RoPE scaling: none

Booster: auto

Train | Evaluate & Predict | Chat | Export

Stage: clip — choose finetune method

Data dir: /home/edgeai/data — choose dataset dir

Dataset: caltech101 — choose dataset

Learning rate: 5e-5 — learning rate

Epochs: 2.0 — epoch

Maximum gradient norm: 1.0

Max samples: 100000

Compute type: bf16

default not to use: ☑ use xpu — whether to use XPU

Cutoff length: 2048

Batch size: 2 — BS

Gradient accumulation: 8

Val size: 0

LR scheduler: cosine

BAdam configurations

Clip_Finetune_tab

Method Group: Finetune — finetune method

clip_finetune method: CLIP_Adapter_hf — method

clip_finetune few_shot_num: 0 (0 means use full dataset)

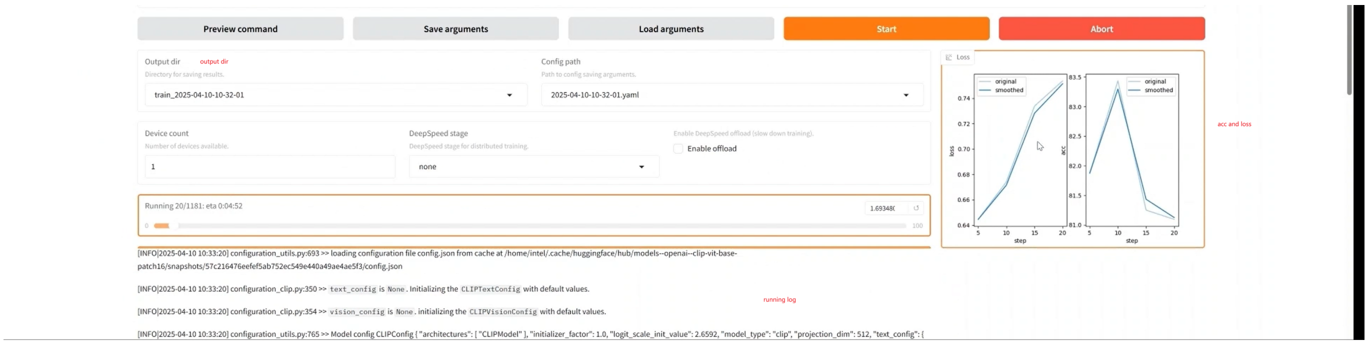
dataset_config_file: /home/edgeai/jlwang/GenAIComps/comps/finetuning/src/integrations/xtune/src/llamafactory/clip_finetune/configs/datasets/

trainer config_file directory: /home/edgeai/jlwang/GenAIComps/comps/finetuning/src/integrations/xtune/src/llamafactory/clip_finetune/configs/trainers/clip_finetune/

Adaclip_finetune_tab

optuna configuration

4.2 Check the result



Output dir
Directory for saving results.
train_2025-04-10-10-32-01

Config path
Path to config saving arguments.
2025-04-10-10-32-01.yaml

Device count
Number of devices available.
1

DeepSpeed stage
DeepSpeed stage for distributed training.
none

Enable DeepSpeed offload (slow down training).
Enable offload

Running 20/1181: eta 0:04:52

```
[INFO|2025-04-10 10:33:20] configuration_utils.py:693 >> loading configuration file config.json from cache at /home/intel/.cache/huggingface/hub/models--openai--clip-vit-base-patch16/snapshots/57c216476eefef5ab752ec549e440a49ae4ae5f3/config.json

[INFO|2025-04-10 10:33:20] configuration_clip.py:350 >> text_config is None. Initializing the CLIPTextConfig with default values.

[INFO|2025-04-10 10:33:20] configuration_clip.py:354 >> vision_config is None. initializing the CLIPVisionConfig with default values.

[INFO|2025-04-10 10:33:20] configuration_utils.py:765 >> Model config CLIPConfig { "architectures": [ "CLIPModel" ], "initializer_factor": 1.0, "logit_scale_init_value": 2.6592, "model_type": "clip", "projection_dim": 512, "text_config": {
```

4.3 Checkpoint and Log

see in GenAIComps/comps/finetuning/src/integrations/xtune/saves/ViT-B/16/clip/${Output dir}

```
$ ls GenAIComps/comps/finetuning/src/integrations/xtune/saves/ViT-B/16/clip/train_2025-05-15-17-18-28
| clip_adapter_hf                          # store checkpoint
| -- checkpoint
| -- model.pth.tar-2
| llamaboard_config.yaml
| tensorboard
| trainer_log.jsonl                        # training log
| training_args.yaml
```

4.4 Load finetuned model

```
cd
GenAIComps/comps/finetuning/src/integrations/xtune/src/llamafactory/clip_finetune
```

run below example to load the model

```
import argparse
import gc
import os
import shutil
import sys

import optuna
import torch
import torch.distributed as dist
import torch.nn.parallel
from dassl.config import get_cfg_default
from dassl.engine import build_trainer
from dassl.utils import collect_env_info, set_random_seed, setup_logger
from datasets import *
from optuna.trial import TrialState
from trainers import *
from train import *
import yaml



if __name__ == "__main__":
    cfg = get_cfg_default()
    extend_cfg(cfg)
    cfg.TRAINER.COOP.XPU = True
    cache_dir =
"/home/edgeai/jlwang/GenAIComps/comps/finetuning/src/integrations/xtune/sav
es/ViT-B/16/clip/train_2025-05-15-17-18-28"
    with open(cache_dir + '/training_args.yaml', 'r') as file:
        data = yaml.safe_load(file)

    cfg.merge_from_file(data["dataset_config_file"] + data["dataset"] +
".yaml")
    cfg.merge_from_file(data["config_file"] + data["model_name_or_path"] +
".yaml")
    cfg.TRAINER.NAME = data["trainer"]
    cfg.DATASET.ROOT = data["root"]
    print(cfg)
    trainer = build_trainer(cfg)


    trainer.load_model(cache_dir , epoch=2)
    print(trainer.model)
```

5. Finetune Clip with SHELL instead of GUI

5.1 How to finetune

You can use our exists finetune script

```
cd
GenAIComps/comps/finetuning/src/integrations/xtune/src/llamafactory/clip_fi
netune
bash scripts/clip_finetune/clip_adapter_hf.sh caltech101 vit_b16 0 xpu >>
test_log.txt
```

Bolow are scripts details

```
#!/bin/bash

# Copyright (C) 2025 Intel Corporation
# SPDX-License-Identifier: Apache-2.0

# custom config
```

```
TRAINER=CLIP_Adapter_hf       # Config train method
DATASET=$1                    # Config dataset
CFG=$2                        # Config finetune param, see sec 3.2
ACCEPT=$3                     # Config how much steop to print acc
DEVICE=$4                     # Config which device you want to use
USE_OPTUNA=$5                 # Config whether to use optuna
device=0
if [ -z $ACCEPT ]; then
    ACCEPT=0
fi
if [ -z $DEVICE ]; then
    DEVICE="cuda"
    device=0
fi
if [ -z $USE_OPTUNA ]; then
    USE_OPTUNA=0
fi
if [ $DEVICE = "XPU" ]; then
    device=1
    ZE_AFFINITY_MASK=0 python train.py \
    --root ${DATA} \
    --trainer ${TRAINER} \
    --dataset-config-file configs/datasets/${DATASET}.yaml \
    --config-file configs/trainers/clip_finetune/${CFG}.yaml \
    --output-dir output/${TRAINER}/${CFG}/${DATASET} \
    --xpu $device \
    --seed 123 \
    --use-optuna $USE_OPTUNA \
    TRAINER.COOP.ACC $ACCEPT \
    TRAINER.COOP.N_CTX 16 \
    TRAINER.COOP.CSC True \
    TRAINER.COOP.CLASS_TOKEN_POSITION end \
    DATASET.NUM_SHOTS 0
else
    CUDA_VISIBLE_DEVICES=0 python train.py \
    --root ${DATA} \
    --trainer ${TRAINER} \
    --dataset-config-file configs/datasets/${DATASET}.yaml \
    --config-file configs/trainers/clip_finetune/${CFG}.yaml \
    --output-dir output/${TRAINER}/${CFG}/${DATASET} \
    --xpu $device \
    --seed 123 \
    --use-optuna $USE_OPTUNA \
    --eval-only \
    TRAINER.COOP.ACC $ACCEPT \
    TRAINER.COOP.N_CTX 16 \
    TRAINER.COOP.CSC True \
    TRAINER.COOP.CLASS_TOKEN_POSITION end \
    DATASET.NUM_SHOTS 16
fi
```

5.2 Check the result

You can see the result in terminal

```
$ cat test_log.txt
....
=> result
* total: 2,465
* correct: 1,635
* accuracy: 66.3%
* error: 33.7%
* macro_f1: 52.3%
=============================finish_test====================
Elapsed: 1:55:05
```

Appendix

Appendix a: Custom Dataset {id=appendix_a}

You need to wite a python file to tell clip how to partition the dataset and put it under `$PATH/comps/finetuning/src/integrations/xtune/src/llamafactory/clip_finetune/datasets`. You can refer to these python file as example.https://github.com/jilongW/Dassl.pytorch/tree/master/clip/datasets After this, please restart xtune.

We use caltech101 as excample:

```
# Copyright (C) 2025 Intel Corporation
# SPDX-License-Identifier: Apache-2.0

import os
import pickle
from collections import OrderedDict

from dassl.data.datasets import DATASET_REGISTRY, DatasetBase, Datum
from dassl.utils import listdir_nohidden, mkdir_if_missing

from .oxford_pets import OxfordPets


@DATASET_REGISTRY.register()
class MiniImageNet(DatasetBase):                    # dataset class

    dataset_dir = "mini-imagenet"                   # dataset folder name

    def __init__(self, cfg):
        root = os.path.abspath(os.path.expanduser(cfg.DATASET.ROOT))
        self.dataset_dir = os.path.join(root, self.dataset_dir)
        self.image_dir = self.dataset_dir
        self.preprocessed = os.path.join(self.dataset_dir,
"preprocessed.pkl")
        self.split_fewshot_dir = os.path.join(self.dataset_dir,
"split_fewshot")
        mkdir_if_missing(self.split_fewshot_dir)

        if os.path.exists(self.preprocessed):       # read from cache
            with open(self.preprocessed, "rb") as f:
                preprocessed = pickle.load(f)
                train = preprocessed["train"]
                test = preprocessed["test"]
                val = preprocessed["val"]
        else:                                       # the first time to run
            # classnames.txt like this "n01440764 tench", the folder name
and lable. It means all picture in this folder are belong to this lable.
            text_file = os.path.join(self.dataset_dir, "classnames.txt")
            classnames = self.read_classnames(text_file)
            # register all train picture
            train = self.read_data(classnames, "train")
            # print(train)
            # Follow standard practice to perform evaluation on the val set
            # Also used as the val set (so evaluate the last-step model)
            test = self.read_data(classnames, "test")
            # print(test)
            val = self.read_data(classnames, "val")
            # print(val)

            # save cache
            preprocessed = {"train": train, "test": test, "val": val}
            with open(self.preprocessed, "wb") as f:
                pickle.dump(preprocessed, f,
protocol=pickle.HIGHEST_PROTOCOL)

        num_shots = cfg.DATASET.NUM_SHOTS
        if num_shots >= 1:
            seed = cfg.SEED
            preprocessed = os.path.join(self.split_fewshot_dir,
f"shot_{num_shots}-seed_{seed}.pkl")

            if os.path.exists(preprocessed):
                print(f"Loading preprocessed few-shot data from
{preprocessed}")
                with open(preprocessed, "rb") as file:
                    data = pickle.load(file)
                    train, val = data["train"], data["val"]
            else:
                train = self.generate_fewshot_dataset(train,
num_shots=num_shots)
                val = self.generate_fewshot_dataset(val,
num_shots=min(num_shots, 4))
                data = {"train": train, "val": val}
                print(f"Saving preprocessed few-shot data to
{preprocessed}")
                with open(preprocessed, "wb") as file:
                    pickle.dump(data, file,
protocol=pickle.HIGHEST_PROTOCOL)
```

```
        subsample = cfg.DATASET.SUBSAMPLE_CLASSES
        train, val, test = OxfordPets.subsample_classes(train, val, test,
subsample=subsample)

        super().__init__(train_x=train, val=val, test=test)

    @staticmethod
    def read_classnames(text_file):
        """Return a dictionary containing
        key-value pairs of <folder name>: <class name>."""
        classnames = OrderedDict()
        with open(text_file, "r") as f:
            lines = f.readlines()
            for line in lines:
                line = line.strip().split(" ")
                folder = line[0]
                classname = " ".join(line[1:])
                classnames[folder] = classname
        return classnames

    def read_data(self, classnames, split_dir):
        split_dir = os.path.join(self.image_dir, split_dir)
        folders = sorted(f.name for f in os.scandir(split_dir) if
f.is_dir())
        items = []

        for label, folder in enumerate(folders):
            imnames = listdir_nohidden(os.path.join(split_dir, folder))
            classname = classnames[folder]
            for imname in imnames:
                impath = os.path.join(split_dir, folder, imname)
                item = Datum(impath=impath, label=label,
classname=classname)
                items.append(item)

        return items
```