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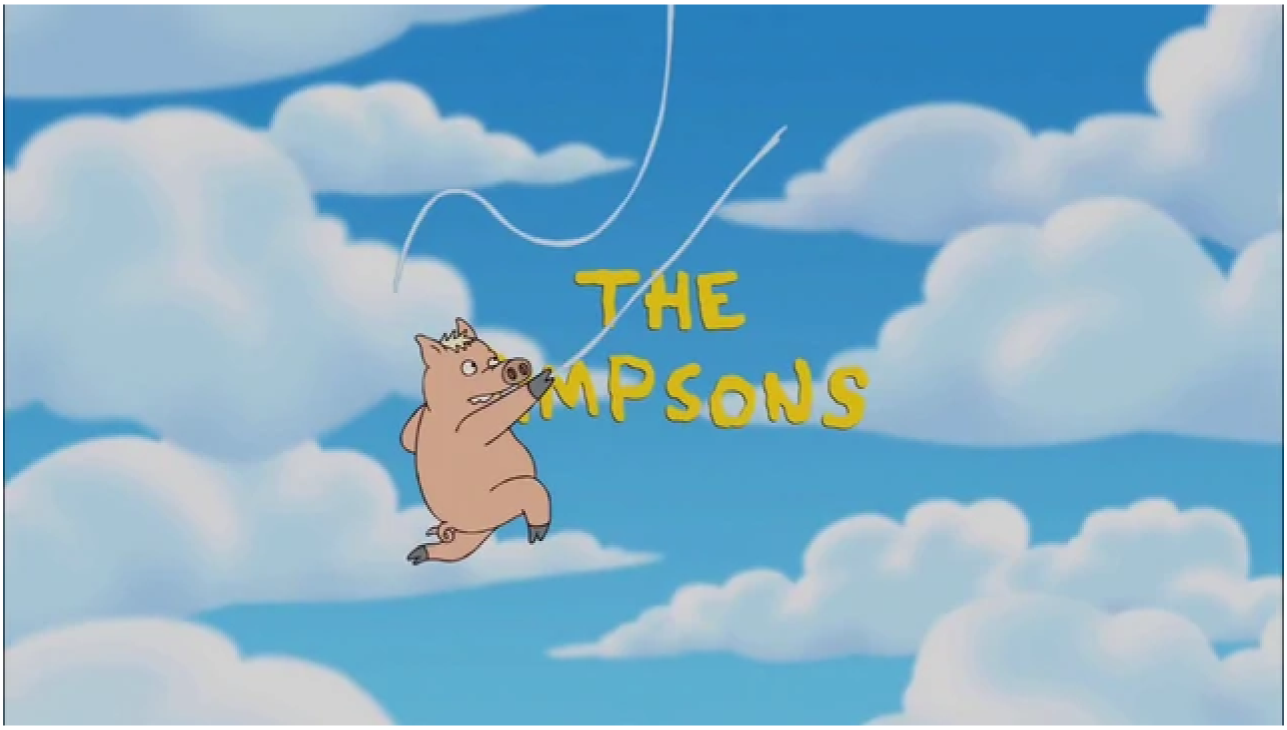
Путешествие по Спрингфилду.

Сегодня вам предстоить помочь телекомпании FOX в обработке их контента. Как вы знаете сериал Симсоны идет на телеэкранах более 25 лет и за это время скопилось очень много видео материала. Персоонажи менялись вместе с изменяющимися графическими технологиями и Гомер 2018 не очень похож на Гомера 1989. Нашей задачей будет научиться классифицировать персонажей проживающих в Спрингфилде. Думаю, что нет смысла представлять каждого из них в отдельности.



Установка зависимостей

```
# ignore deprication warnings
import warnings
warnings.filterwarnings(action='ignore', category=DeprecationWarning)

# standard python modules
import os, sys
import time


# standard ml modules
import random
import numpy as np
import pandas as pd
from matplotlib import pyplot as plt, colors
# work in interactive moode
```

```
%matplotlib inline


# loading files (in parallel)
from pathlib import Path
from multiprocessing.pool import ThreadPool


# working with images
import PIL
from PIL import Image
from skimage import io

# preprocessing
from sklearn.preprocessing import LabelEncoder


# torch
import torch
import torch.nn as nn
from torch.utils.data import Dataset, DataLoader
import torch.optim as optim
from torch.optim import lr_scheduler
# torchvision
import torchvision
from torchvision import transforms


# interacrive timimg
from tqdm import tqdm, tqdm_notebook

# saving models
import pickle
import copy
```

```
# we will verify that GPU is enabled for this notebook
# following should print: CUDA is available!  Training on GPU ...
#
# if it prints otherwise, then you need to enable GPU:
# from Menu > Runtime > Change Runtime Type > Hardware Accelerator > GPU

train_on_gpu = torch.cuda.is_available()

if not train_on_gpu:
    print('CUDA is not available.  Training on CPU ...')
else:
    print('CUDA is available!  Training on GPU ...')
```

```
CUDA is available!  Training on GPU ...
```

Double-click (or enter) to edit

```
# разные режимы датасета
DATA_MODES = ['train', 'val', 'test']
# все изображения будут масштабированы к размеру 224x224 px
RESCALE_SIZE = 224
```

```
# работаем на видеокарте
DEVICE = torch.device("cuda" if torch.cuda.is_available() else "cpu")
```

```
DEVICE
```

```
device(type='cuda')
```

```
from google.colab import drive
drive.mount('/content/gdrive/')
```

```
Mounted at /content/gdrive/
```

```
!unzip -q /content/gdrive/MyDrive/journey-springfield.zip -d journey-springfield
```

```
!nvidia-smi
import torch
torch.cuda.is_available()
```

```
Sun Nov 28 07:12:38 2021
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 495.44       Driver Version: 460.32.03    CUDA Version: 11.2     |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|                               |                      |               MIG M. |
|===============================+======================+======================|
|   0  Tesla K80           Off  | 00000000:00:04.0 Off |                    0 |
| N/A   37C    P8    28W / 149W |      3MiB / 11441MiB |      0%      Default |
|                               |                      |                  N/A |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                                  |
|  GPU   GI   CI        PID   Type   Process name                  GPU Memory |
|        ID   ID                                                   Usage      |
|=============================================================================|
|  No running processes found                                                 |
+-----------------------------------------------------------------------------+
True
```

В нашем тесте будет 990 картнок, для которых вам будет необходимо предсказать класс.

```
# разные режимы датасета
DATA_MODES = ['train', 'val', 'test']
# все изображения будут масштабированы к размеру 224x224 px
RESCALE_SIZE = 224
# работаем на видеокарте
DEVICE = torch.device("cuda")
```

https://jhui.github.io/2018/02/09/PyTorch-Data-loading-preprocess_torchvision/

Ниже мы исспользуем враппер над датасетом для удобной работы. Вам стоит понимать, что происходит с LabelEncoder и с torch.Transformation.

ToTensor конвертирует PIL Image с параметрами в диапазоне [0, 255] (как все пиксели) в FloatTensor размера (C x H x W) [0,1] , затем производится масштабирование: $input = \frac{input-\mu}{\text{standard deviation}}$, константы - средние и дисперсии по каналам на основе ImageNet

Стоит также отметить, что мы переопределяем метод **getitem** для удобства работы с данной структурой данных. Также используется LabelEncoder для преобразования строковых меток классов в id и обратно. В описании датасета указано, что картинки разного размера, так как брались напрямую с видео, поэтому следуем привести их к одному размер (это делает метод _prepare_sample)

```
class SimpsonsDataset(Dataset):
    """
    Class to work with image dastaset, which
    - loads them form the folders in parallel
    - converts to PyTorch tensors
    - scales the tensors to have mean = 0, standard deviation = 1
    """
    def __init__(self, files, mode):
        super().__init__()
        self.files = sorted(files) # list of files to be loaded
        self.mode = mode           # working mode

        if self.mode not in DATA_MODES:
            print(f"{self.mode} is not correct; correct modes: {DATA_MODES}")
            raise NameError

        self.len_ = len(self.files)

        self.label_encoder = LabelEncoder()

        if self.mode != 'test':
            self.labels = [path.parent.name for path in self.files]
            self.label_encoder.fit(self.labels)

            with open('label_encoder.pkl', 'wb') as le_dump_file:
                  pickle.dump(self.label_encoder, le_dump_file)


    def __len__(self):
        return self.len_


    def load_sample(self, file):
        image = Image.open(file)
        image.load()
        return image


    def _prepare_sample(self, image):
        image = image.resize((RESCALE_SIZE, RESCALE_SIZE))
        return np.array(image)


    def __getitem__(self, index):
        # converts to PyTorch tensors and normalises the input
```

```
        data_transforms = {
            'train': transforms.Compose([
                transforms.Resize(size=(RESCALE_SIZE, RESCALE_SIZE)),
                transforms.RandomRotation(degrees=30),
                transforms.RandomHorizontalFlip(),
                transforms.ColorJitter(hue=.1, saturation=.1),
                transforms.ToTensor(),
                transforms.Normalize([0.485, 0.456, 0.406], [0.229, 0.224, 0.225])
            ]),
            'val_test': transforms.Compose([
                transforms.Resize(size=(RESCALE_SIZE, RESCALE_SIZE)),
                transforms.ToTensor(),
                transforms.Normalize([0.485, 0.456, 0.406], [0.229, 0.224, 0.225])
            ]),
        }

        transform = (data_transforms['train'] if self.mode == 'train' else data_transforms['val_t

        x = self.load_sample(self.files[index])  # load image
        x = transform(x)                          # apply transform defined above

        if self.mode == 'test':
            return x
        else:
            label = self.labels[index]
            label_id = self.label_encoder.transform([label])
            y = label_id.item()
            return x, y
```

```
def imshow(inp, title=None, plt_ax=plt, default=False):
    """Imshow для тензоров"""
    inp = inp.numpy().transpose((1, 2, 0))
    mean = np.array([0.485, 0.456, 0.406])
    std = np.array([0.229, 0.224, 0.225])
    inp = std * inp + mean
    inp = np.clip(inp, 0, 1)
    plt_ax.imshow(inp)
    if title is not None:
        plt_ax.set_title(title)
    plt_ax.grid(False)
```

```
TRAIN_DIR = Path('/content/journey-springfield/train')
TEST_DIR = Path('/content/journey-springfield/testset')

train_val_files = sorted(list(TRAIN_DIR.rglob('*.jpg')))
test_files = sorted(list(TEST_DIR.rglob('*.jpg')))
```

```
print(len(train_val_files), 'train files')
train_val_files[:5]
```

```
20933 train files
[PosixPath('/content/journey-springfield/train/simpsons_dataset/abraham_grampa_simpson/pic_000
 PosixPath('/content/journey-springfield/train/simpsons_dataset/abraham_grampa_simpson/pic_000
 PosixPath('/content/journey-springfield/train/simpsons_dataset/abraham_grampa_simpson/pic_000
 PosixPath('/content/journey-springfield/train/simpsons_dataset/abraham_grampa_simpson/pic_000
 PosixPath('/content/journey-springfield/train/simpsons_dataset/abraham_grampa_simpson/pic_000
```

```
print(len(test_files), 'test files')
test_files[:5]
```

```
991 test files
[PosixPath('/content/journey-springfield/testset/testset/img0.jpg'),
 PosixPath('/content/journey-springfield/testset/testset/img1.jpg'),
 PosixPath('/content/journey-springfield/testset/testset/img10.jpg'),
 PosixPath('/content/journey-springfield/testset/testset/img100.jpg'),
 PosixPath('/content/journey-springfield/testset/testset/img101.jpg')]
```

```
# path.parent.name returns a folder in which the image is, which corresponds to the label in nthi
train_val_labels = [path.parent.name for path in train_val_files]
```

```
print(len(train_val_labels), 'train_val_labels')
train_val_labels[:5]
```

```
20933 train_val_labels
['abraham_grampa_simpson',
 'abraham_grampa_simpson',
 'abraham_grampa_simpson',
 'abraham_grampa_simpson',
 'abraham_grampa_simpson']
```

```
from sklearn.model_selection import train_test_split
train_files, val_files = train_test_split(train_val_files, test_size=0.20, stratify=train_val_lab
```

```
val_dataset = SimpsonsDataset(val_files, mode='val')
```

Давайте посмотрим на наших героев внутри датасета.

```
fig, ax = plt.subplots(nrows=3, ncols=3,figsize=(8, 8), \
                        sharey=True, sharex=True)
for fig_x in ax.flatten():
    random_characters = int(np.random.uniform(0,1000))
    im_val, label = val_dataset[random_characters]
    img_label = " ".join(map(lambda x: x.capitalize(),\
                val_dataset.label_encoder.inverse_transform([label])[0].split('_')))
    imshow(im_val.data.cpu(), \
          title=img_label,plt_ax=fig_x)
```

Можете добавить ваши любимые сцены и классифицировать их. (веселые результаты можно кидать в чат)


```
def fit_epoch(model, train_loader, criterion, optimizer):
    # initialize tracked variables
    running_loss = 0.0
    running_corrects = 0
    processed_data = 0

    for inputs, labels in train_loader:
        inputs = inputs.to(DEVICE)
        labels = labels.to(DEVICE)

        # reset the gradient
        optimizer.zero_grad()

        # predictions (probabilities), loss, backprop
        outputs = model(inputs)
        loss = criterion(outputs, labels)
        loss.backward()

        # weights update
        optimizer.step()

        # predictions (classes)
        preds = torch.argmax(outputs, 1)

        # record tracked items
        running_loss += loss.item() * inputs.size(0)
        running_corrects += torch.sum(preds == labels.data)
        processed_data += inputs.size(0)

    # record train loss and train accuracy
    train_loss = running_loss / processed_data
    train_acc = running_corrects.cpu().numpy() / processed_data
    return train_loss, train_acc
```

```
def eval_epoch(model, val_loader, criterion):
    # set model model into the evaluation mode (e.g. for Dropout)
    model.eval()

    # initialize tracked variables
    running_loss = 0.0
```

```
    running_corrects = 0
    processed_size = 0

    for inputs, labels in val_loader:
        inputs = inputs.to(DEVICE)
        labels = labels.to(DEVICE)

        with torch.set_grad_enabled(False):
            outputs = model(inputs)
            loss = criterion(outputs, labels)
            preds = torch.argmax(outputs, 1)

        # record tracked items
        running_loss += loss.item() * inputs.size(0)
        running_corrects += torch.sum(preds == labels.data)
        processed_size += inputs.size(0)

    # record val loss and val accuracy
    val_loss = running_loss / processed_size
    val_acc = running_corrects.double() / processed_size
    return val_loss, val_acc
```

```
def train(train_dataset, val_dataset, model, criterion,
          epochs, batch_size, optimizer, scheduler,
          shuffle=True, sampler=None, patience=5):

    # to record the total training time
    since = time.time()

    # note: 4 workers loading the data
    train_loader = DataLoader(train_dataset, batch_size=batch_size, shuffle=shuffle, sampler=samp
    val_loader = DataLoader(val_dataset, batch_size=batch_size, shuffle=False, num_workers=4)

    # init variables to store best model weights, best accuracy, best epoch number, epochs since
    best_model_wts = copy.deepcopy(model.state_dict())
    best_loss = 10
    best_epoch = 0
    epochs_since_best = 0

    # history and log
    history = []
    log_template = "\nEpoch {ep:03d} train_loss: {t_loss:0.4f} \
    val_loss {v_loss:0.4f} train_acc {t_acc:0.4f} val_acc {v_acc:0.4f}"

    with tqdm(desc="epoch", total=epochs) as pbar_outer:

        for epoch in range(1, epochs+1):
            print(f"epoch {epoch}:\n")

            print("Fitting on train data...")
            # all arguments except train loader are from parameters passed to train() arguments
            train_loss, train_acc = fit_epoch(model, train_loader, criterion, optimizer)
            print("train loss:", train_loss)

            print("Evaluating on validation data...")
            val_loss, val_acc = eval_epoch(model, val_loader, criterion)
            print("val loss:", val_loss)
```

```
            # record history
            history.append((train_loss, train_acc, val_loss, val_acc))

            # update learning rate for the optimizer
            scheduler.step()

            # display learning status
            pbar_outer.update(1)
            tqdm.write(log_template.format(ep=epoch, t_loss=train_loss,\
                                           v_loss=val_loss, t_acc=train_acc, v_acc=val_acc))

            # deep copy the model if it acheives the best validation performance
            if val_loss < best_loss:
                best_acc = val_loss
                best_epoch = epoch
                best_model_wts = copy.deepcopy(model.state_dict())
                print()
            else:
                epochs_since_best += 1

            # early stopping
            if epochs_since_best > patience:
                print(f'Stopping training. The validation metric has not improved for {patience}
                break


    time_elapsed = time.time() - since
    print('Training complete in {:.0f}m {:.0f}s'.format(
    time_elapsed // 60, time_elapsed % 60))
    print('Best val loss: {:4f}'.format(best_loss))
    print('Best epoch: {}'.format(best_epoch))

    # load best model weights
    model.load_state_dict(best_model_wts)

    return history
```

```
def predict(model, test_loader):
    with torch.no_grad():
        logits = []

        for inputs in test_loader:
            inputs = inputs.to(DEVICE)
            model.eval()
            outputs = model(inputs).cpu()
            logits.append(outputs)

    probs = nn.functional.softmax(torch.cat(logits), dim=-1).numpy()
    return probs
```

```
N_CLASSES = len(np.unique(train_val_labels))
```

```
if val_dataset is None:
    val_dataset = SimpsonsDataset(val_files, mode='val')

train_dataset = SimpsonsDataset(train_files, mode='train')
```

Training only the last layer

```
1 !pip install efficientnet_pytorch
```

```
Collecting efficientnet_pytorch
  Downloading efficientnet_pytorch-0.7.1.tar.gz (21 kB)
Requirement already satisfied: torch in /usr/local/lib/python3.7/dist-packages (from efficientn
Requirement already satisfied: typing-extensions in /usr/local/lib/python3.7/dist-packages (fro
Building wheels for collected packages: efficientnet-pytorch
  Building wheel for efficientnet-pytorch (setup.py) ... done
  Created wheel for efficientnet-pytorch: filename=efficientnet_pytorch-0.7.1-py3-none-any.whl
  Stored in directory: /root/.cache/pip/wheels/0e/cc/b2/49e74588263573ff778da58cc99b9c6349b496
Successfully built efficientnet-pytorch
Installing collected packages: efficientnet-pytorch
Successfully installed efficientnet-pytorch-0.7.1
```

```
1 from efficientnet_pytorch import EfficientNet
```

```
1 model_name = 'efficientnet-b2'
```

```
1 model = EfficientNet.from_pretrained(model_name)
```

```
Downloading: "https://github.com/lukemelas/EfficientNet-PyTorch/releases/download/1.0/efficient
```

100% 35.1M/35.1M [00:00<00:00, 92.5MB/s]

```
Loaded pretrained weights for efficientnet-b2
```

```
1 model
```

```
        (static_padding): Identity()
      )
      (_bn2): BatchNorm2d(208, eps=0.001, momentum=0.010000000000000009, affine=True, track_
      (_swish): MemoryEfficientSwish()
    )
    (17): MBConvBlock(
      (_expand_conv): Conv2dStaticSamePadding(
        208, 1248, kernel_size=(1, 1), stride=(1, 1), bias=False
        (static_padding): Identity()
      )
      (_bn0): BatchNorm2d(1248, eps=0.001, momentum=0.010000000000000009, affine=True, track
      (_depthwise_conv): Conv2dStaticSamePadding(
        1248, 1248, kernel_size=(5, 5), stride=(1, 1), groups=1248, bias=False
        (static_padding): ZeroPad2d(padding=(2, 2, 2, 2), value=0.0)
      )
      (_bn1): BatchNorm2d(1248, eps=0.001, momentum=0.010000000000000009, affine=True, track
      (_se_reduce): Conv2dStaticSamePadding(
        1248, 52, kernel_size=(1, 1), stride=(1, 1)
        (static_padding): Identity()
      )
      (_se_expand): Conv2dStaticSamePadding(
        52, 1248, kernel_size=(1, 1), stride=(1, 1)
        (static_padding): Identity()
      )
      (_project_conv): Conv2dStaticSamePadding(
        1248, 208, kernel_size=(1, 1), stride=(1, 1), bias=False
        (static_padding): Identity()
      )
      (_bn2): BatchNorm2d(208, eps=0.001, momentum=0.010000000000000009, affine=True, track_
```

```
          (_swish): MemoryEfficientSwish()
        )
        (18): MBConvBlock(
          (_expand_conv): Conv2dStaticSamePadding(
            208, 1248, kernel_size=(1, 1), stride=(1, 1), bias=False
            (static_padding): Identity()
          )
          (_bn0): BatchNorm2d(1248, eps=0.001, momentum=0.010000000000000009, affine=True, track
          (_depthwise_conv): Conv2dStaticSamePadding(
            1248, 1248, kernel_size=(5, 5), stride=(1, 1), groups=1248, bias=False
            (static_padding): ZeroPad2d(padding=(2, 2, 2, 2), value=0.0)
          )
          (_bn1): BatchNorm2d(1248, eps=0.001, momentum=0.010000000000000009, affine=True, track
          (_se_reduce): Conv2dStaticSamePadding(
            1248, 52, kernel_size=(1, 1), stride=(1, 1)
            (static_padding): Identity()
          )
          (_se_expand): Conv2dStaticSamePadding(
            52, 1248, kernel_size=(1, 1), stride=(1, 1)
            (static_padding): Identity()
          )
          (_project_conv): Conv2dStaticSamePadding(
            1248, 208, kernel_size=(1, 1), stride=(1, 1), bias=False
            (static_padding): Identity()
          )
          (_bn2): BatchNorm2d(208, eps=0.001, momentum=0.010000000000000009, affine=True, track_
          (_swish): MemoryEfficientSwish()
        )
```

```python
for param in model.parameters():
    param.requires_grad = False

# Parameters of newly constructed modules have requires_grad=True by default
num_ftrs = model._fc.in_features
model._fc = nn.Linear(num_ftrs, N_CLASSES)

# to GPU
model = model.to(DEVICE)

# loss
criterion = nn.CrossEntropyLoss()

# learning rate optimizer
optimizer = torch.optim.AdamW(model.parameters())

# scheduler for the lr optimizer
scheduler = torch.optim.lr_scheduler.StepLR(optimizer, 3, 0.5)
```

```python
model._fc
```

```
Linear(in_features=1408, out_features=42, bias=True)
```

```python
feature_extr_epochs = 3
```

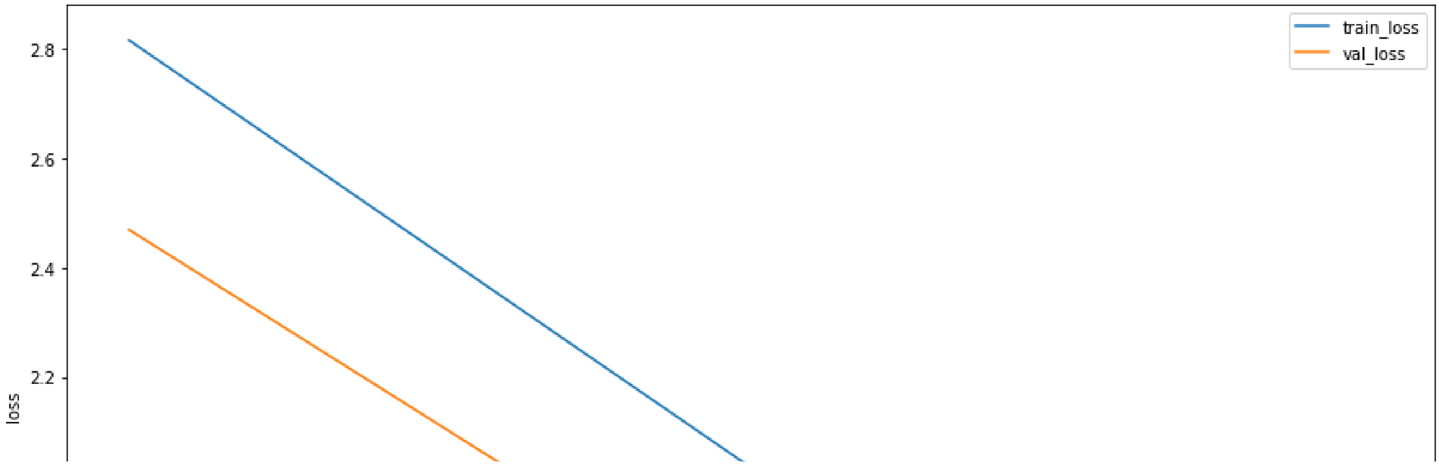
```python
history_feature_extr = train(train_dataset, val_dataset, model=model, criterion=criterion,
                             epochs=feature_extr_epochs, batch_size=256, optimizer=optimizer, sch
```

```
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:481: UserWarning: This Da
```

```
  cpuset_checked))
epoch:   0%|          | 0/3 [00:00<?, ?it/s]epoch 1:

Fitting on train data...
train loss: 2.816080071970822
Evaluating on validation data...
epoch:  33%|███▎      | 1/3 [03:32<07:04, 212.24s/it]val loss: 2.4697439391544105

Epoch 001 train_loss: 2.8161     val_loss 2.4697 train_acc 0.3197 val_acc 0.4550

epoch 2:

Fitting on train data...
train loss: 2.0353817675655552
Evaluating on validation data...
epoch:  67%|██████▋   | 2/3 [07:05<03:32, 212.87s/it]val loss: 1.7548837868444727

Epoch 002 train_loss: 2.0354     val_loss 1.7549 train_acc 0.5463 val_acc 0.6124

epoch 3:

Fitting on train data...
train loss: 1.5977416844631656
Evaluating on validation data...
epoch: 100%|██████████| 3/3 [10:44<00:00, 214.98s/it]val loss: 1.486225349851289

Epoch 003 train_loss: 1.5977     val_loss 1.4862 train_acc 0.6273 val_acc 0.6599

Training complete in 10m 45s
Best val loss: 10.000000
Best epoch: 3
```

```
loss, acc, val_loss, val_acc = zip(*history_feature_extr)
```

```
plt.figure(figsize=(15, 9))
plt.plot(loss, label="train_loss")
plt.plot(val_loss, label="val_loss")
plt.legend(loc='best')
plt.xlabel("epochs")
plt.ylabel("loss")
plt.show()
```



Training all layers

```
for param in model.parameters():
    param.requires_grad = True
```

```
finetuning_epochs = 20
```

```
history_fine_tune = train(train_dataset=train_dataset, val_dataset=val_dataset, model=model, crit
                          epochs=finetuning_epochs, batch_size=16, optimizer=optimizer, scheduler
```

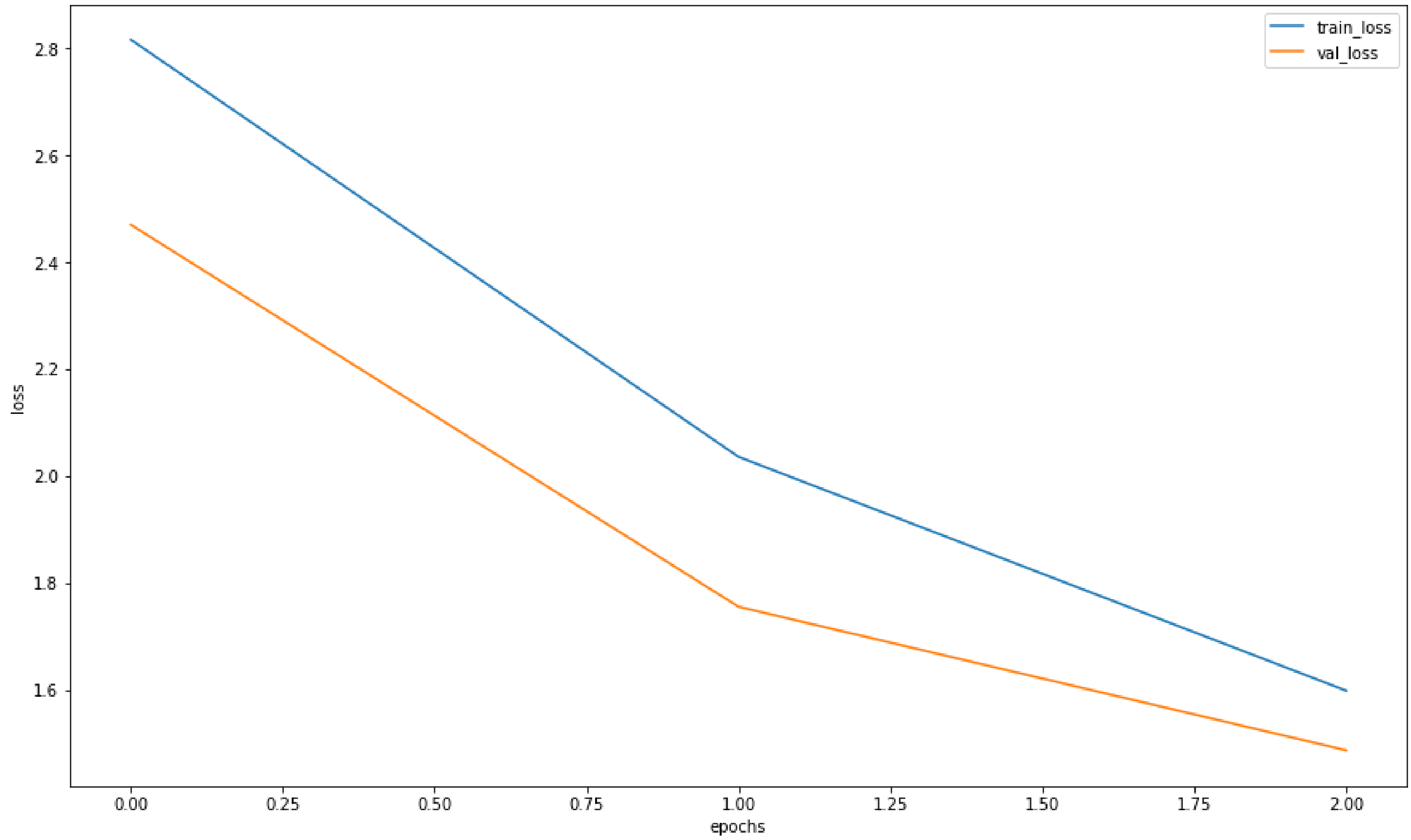
```
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:481: UserWarning: This Da
  cpuset_checked))
epoch:   0%|          | 0/20 [00:00<?, ?it/s]epoch 1:

Fitting on train data...
train loss: 0.4610751473526055
Evaluating on validation data...
epoch:   5%|▌         | 1/20 [07:39<2:25:36, 459.83s/it]val loss: 0.1900292584273099

Epoch 001 train_loss: 0.4611     val_loss 0.1900 train_acc 0.8803 val_acc 0.9520

epoch 2:

Fitting on train data...
train loss: 0.227955534666559
Evaluating on validation data...
epoch:  10%|█         | 2/20 [15:20<2:18:04, 460.23s/it]val loss: 0.16228132652883298

Epoch 002 train_loss: 0.2280     val_loss 0.1623 train_acc 0.9402 val_acc 0.9577

epoch 3:

Fitting on train data...
train loss: 0.19532413977905666
Evaluating on validation data...
epoch:  15%|█▌        | 3/20 [23:00<2:10:24, 460.27s/it]val loss: 0.1761299595274226

Epoch 003 train_loss: 0.1953     val_loss 0.1761 train_acc 0.9483 val_acc 0.9570

epoch 4:

Fitting on train data...
train loss: 0.07108287800511714
Evaluating on validation data...
epoch:  20%|██        | 4/20 [30:40<2:02:44, 460.27s/it]val loss: 0.10210113575921802

Epoch 004 train_loss: 0.0711     val_loss 0.1021 train_acc 0.9827 val_acc 0.9756

epoch 5:

Fitting on train data...
train loss: 0.05060067677520271
Evaluating on validation data...
epoch:  25%|██▌       | 5/20 [38:21<1:55:05, 460.37s/it]val loss: 0.15314130060279219

Epoch 005 train_loss: 0.0506     val_loss 0.1531 train_acc 0.9870 val_acc 0.9644

epoch 6:

Fitting on train data...
train loss: 0.07118963005940708
Evaluating on validation data...
```

```python
loss, acc, val_loss, val_acc = zip(*history_fine_tune)
```

```
Epoch 006 train_loss: 0.0712     val_loss 0.1372 train_acc 0.9799 val_acc 0.9721
```

```python
plt.figure(figsize=(15, 9))
plt.plot(loss, label="train_loss")
plt.plot(val_loss, label="val_loss")
plt.legend(loc='best')
plt.xlabel("epochs")
plt.ylabel("loss")


```

```
plt.savefig(f"{model_name}_{feature_extr_epochs}FeatureExtrEpochs-{finetuning_epochs}FinetuningEp
plt.show()
```




```
f"{model_name}_{feature_extr_epochs}FeatureExtrEpochs-{finetuning_epochs}FinetuningEpochs-Learnin
```

```
'efficientnet-b2_3FeatureExtrEpochs-20FinetuningEpochs-LearningCurve.png'
```

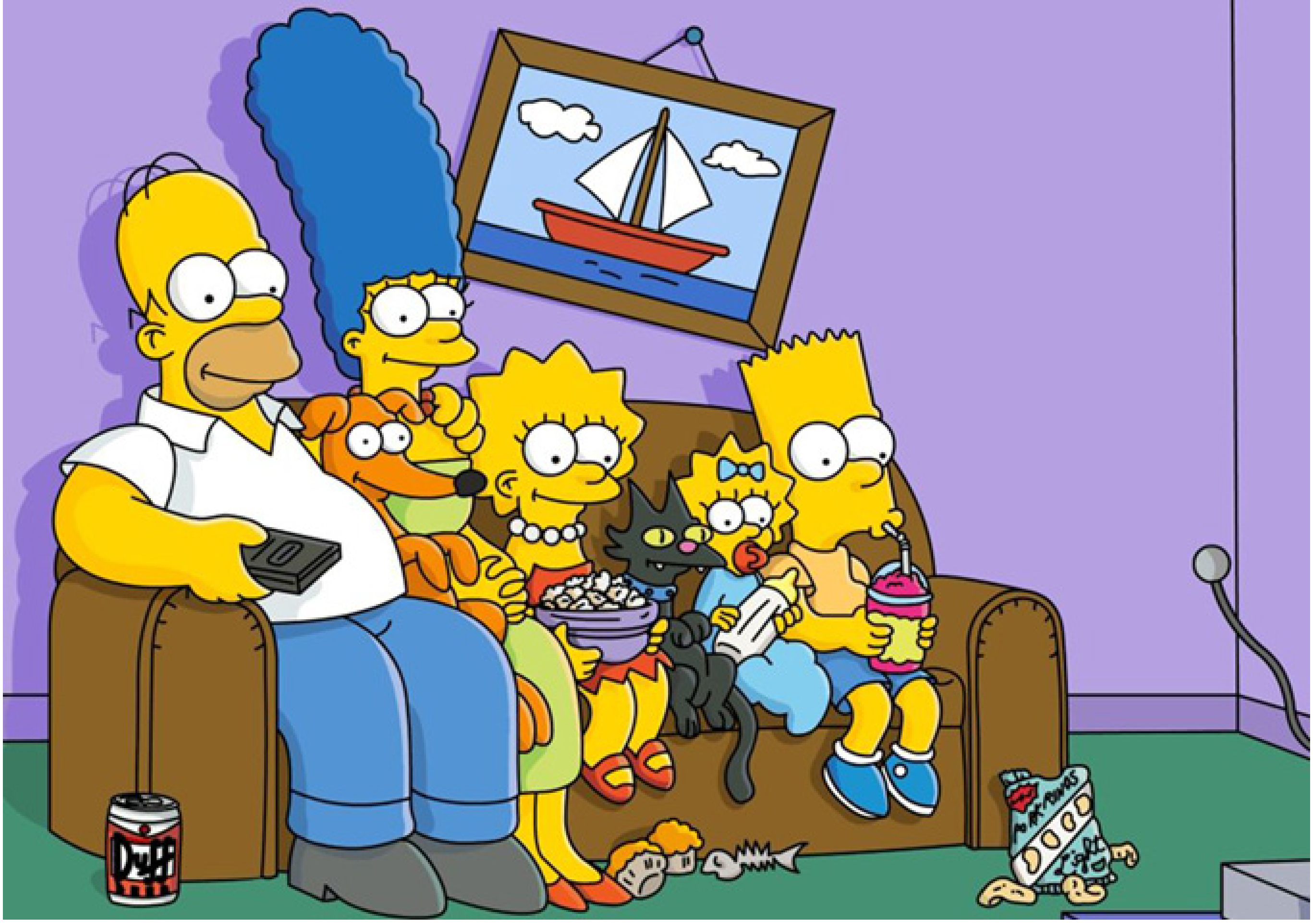
```
# save the weights of our net
model_weights = copy.deepcopy(model.state_dict())
torch.save(model_weights, f"{model_name}_{feature_extr_epochs}FeatureExtrEpochs-{finetuning_epoch
```

```
%ls
```

```
efficientnet-b2_3FeatureExtrEpochs-20FinetuningEpochs-LearningCurve.png
efficientnet-b2_3FeatureExtrEpochs-20FinetuningEpochs-weights.pth
gdrive/
journey-springfield/
label_encoder.pkl
sample_data/
```

```
# загружаем сохраненное состояние весов нейросети
model.load_state_dict(torch.load(f"{model_name}_{feature_extr_epochs}FeatureExtrEpochs-{finetunin
```

```
<All keys matched successfully>
```



Хорошо бы понять, как сделать сабмит. У нас есть сеть и методы eval у нее, которые позволяют перевести сеть в режим предсказания. Стоит понимать, что у нашей модели на последнем слое стоит softmax, которые позволяет получить вектор вероятностей того, что объект относится к тому или иному классу. Давайте воспользуемся этим.

```
def predict_one_sample(model, inputs, device=DEVICE):
    """Предсказание, для одной картинки"""
    with torch.no_grad():
        inputs = inputs.to(device)
        model.eval()
        logit = model(inputs).cpu()
        probs = torch.nn.functional.softmax(logit, dim=-1).numpy()
    return probs
```

```
random_characters = int(np.random.uniform(0,1000))
ex_img, true_label = val_dataset[random_characters]
probs_im = predict_one_sample(model, ex_img.unsqueeze(0))
```

```
idxs = list(map(int, np.random.uniform(0,1000, 20)))
imgs = [val_dataset[id][0].unsqueeze(0) for id in idxs]

probs_ims = predict(model, imgs)
```

```
actual_labels = [val_dataset[id][1] for id in idxs]
actual_labels
```

```
[4, 6, 0, 4, 6, 7, 4, 0, 0, 6, 4, 1, 6, 4, 6, 6, 0, 6, 6, 4]
```

```
y_pred = np.argmax(probs_ims, -1)
y_pred
```

```
array([4, 6, 0, 4, 6, 7, 4, 0, 0, 6, 4, 1, 6, 4, 6, 6, 0, 6, 6, 4])
```

```
label_encoder = pickle.load(open("label_encoder.pkl", 'rb'))
```

```
actual_class = [label_encoder.classes_[i] for i in actual_labels]
actual_class
```

```
['bart_simpson',
 'charles_montgomery_burns',
 'abraham_grampa_simpson',
 'bart_simpson',
 'charles_montgomery_burns',
 'chief_wiggum',
 'bart_simpson',
 'abraham_grampa_simpson',
 'abraham_grampa_simpson',
 'charles_montgomery_burns',
 'bart_simpson',
 'agnes_skinner',
 'charles_montgomery_burns',
 'bart_simpson',
 'charles_montgomery_burns',
 'charles_montgomery_burns',
 'abraham_grampa_simpson',
 'charles_montgomery_burns',
 'charles_montgomery_burns',
 'bart_simpson']
```

```
preds_class = [label_encoder.classes_[i] for i in y_pred]
preds_class
```

```
['bart_simpson',
 'charles_montgomery_burns',
 'abraham_grampa_simpson',
 'bart_simpson',
 'charles_montgomery_burns',
 'chief_wiggum',
 'bart_simpson',
 'abraham_grampa_simpson',
 'abraham_grampa_simpson',
 'charles_montgomery_burns',
 'bart_simpson',
 'agnes_skinner',
 'charles_montgomery_burns',
 'bart_simpson',
 'charles_montgomery_burns',
 'charles_montgomery_burns',
 'abraham_grampa_simpson',
 'charles_montgomery_burns',
 'charles_montgomery_burns',
 'bart_simpson']
```

```
from sklearn.metrics import f1_score

f1_score(actual_class, preds_class, average='weighted')
```

1.0

```
import matplotlib.patches as patches
from matplotlib.font_manager import FontProperties

fig, ax = plt.subplots(nrows=3, ncols=3,figsize=(12, 12), \
                        sharey=True, sharex=True)
for fig_x in ax.flatten():
    random_characters = int(np.random.uniform(0,1000))
    im_val, label = val_dataset[random_characters]
    img_label = " ".join(map(lambda x: x.capitalize(),\
                val_dataset.label_encoder.inverse_transform([label])[0].split('_')))



    imshow(im_val.data.cpu(), \
          title=img_label,plt_ax=fig_x)

    actual_text = "Actual : {}".format(img_label)

    fig_x.add_patch(patches.Rectangle((0, 53),86,35,color='white'))
    font0 = FontProperties()
    font = font0.copy()
    font.set_family("fantasy")
    prob_pred = predict_one_sample(model, im_val.unsqueeze(0))
    predicted_proba = np.max(prob_pred)*100
    y_pred = np.argmax(prob_pred)

    predicted_label = label_encoder.classes_[y_pred]
    predicted_label = predicted_label[:len(predicted_label)//2] + '\n' + predicted_label[len(pred
    predicted_text = "{} : {:.0f}%".format(predicted_label,predicted_proba)

    fig_x.text(1, 59, predicted_text , horizontalalignment='left', fontproperties=font,
                    verticalalignment='top',fontsize=8, color='black',fontweight='bold')
```

Попробуйте найти те классы, которые сеть не смогла расспознать. Изучите данную проблему, это понадобится в дальнейшем.

Submit на Kaggle


```
test_dataset = SimpsonsDataset(test_files, mode="test")
test_loader = DataLoader(test_dataset, shuffle=False, batch_size=64, num_workers=4)
probs = predict(model, test_loader)


preds = label_encoder.inverse_transform(np.argmax(probs, axis=1))
test_filenames = [path.name for path in test_dataset.files]
```

```
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:481: UserWarning: This Da
```

```
    cpuset_checked))
```

```
! ls
```

```
efficientnet-b2_3FeatureExtrEpochs-20FinetuningEpochs-LearningCurve.png
efficientnet-b2_3FeatureExtrEpochs-20FinetuningEpochs-weights.pth
gdrive
journey-springfield
label_encoder.pkl
sample_data
```

```
import pandas as pd
sample_submit = pd.read_csv("/content/journey-springfield/sample_submission.csv")
sample_submit.head()
```

	Id	Expected
0	img0.jpg	bart_simpson
1	img1.jpg	bart_simpson
2	img2.jpg	bart_simpson
3	img3.jpg	bart_simpson
4	img4.jpg	bart_simpson

```
my_submit = pd.DataFrame({'Id': test_filenames, 'Expected': preds})
print(my_submit.shape)
my_submit.head()
```

```
(991, 2)
```

	Id	Expected
0	img0.jpg	nelson_muntz
1	img1.jpg	bart_simpson
2	img10.jpg	ned_flanders
3	img100.jpg	chief_wiggum
4	img101.jpg	apu_nahasapeemapetilon

```
my_submit.to_csv(f"{model_name}_{feature_extr_epochs}FeatureExtrEpochs-{finetuning_epochs}submiss
```

```
f"{model_name}_{feature_extr_epochs}FeatureExtrEpochs-{finetuning_epochs}FinetuningEpochs-submiss
```

```
'efficientnet-b2_3FeatureExtrEpochs-20FinetuningEpochs-submission.csv'
```

```
f"{model_name}_{feature_extr_epochs}FeatureExtrEpochs-{finetuning_epochs}FinetuningEpochs-weights
f"{model_name}_{feature_extr_epochs}FeatureExtrEpochs-{finetuning_epochs}FinetuningEpochs-Learnin
f"{model_name}_{feature_extr_epochs}FeatureExtrEpochs-{finetuning_epochs}FinetuningEpochs-submiss
```

```
'efficientnet-b2_3FeatureExtrEpochs-20FinetuningEpochs-submission.csv'
```

1

0s completed at 11:53 AM