Ахтемзянов Рафаэль. Для отбора на курс Deep Learning Advanced 2023


```
import torch
import numpy as np
from collections import namedtuple
import pdb
from functools import wraps
from time import time as _timenow
from sys import stderr
import os
import pickle
import math
from PIL import Image
from operator import eq
import cv2
import random
import logging
import json
import math
from warnings import warn
import re
import string
!pip install textdistance
from textdistance import levenshtein as lev

device = torch.device('cuda:0' if torch.cuda.is_available() else 'cpu')


def similarity(word1, word2):
    return lev.normalized_distance(word1, word2)

def gmkdir(path):
    if not os.path.exists(path):
        os.makedirs(path)


def corrupt(x):
    if random.random() > 0.5:
        noise = np.random.binomial(1, 1.0 - 0.2, size=x.size())
        result = x.clone()
        result  *= noise
        return result
    return x

def gaussian(images):
    if random.random() > 0.5:
        mean, var = 0, 0.1
        stddev = var**2
        noise = images.data.new(images.size()).normal_(mean, stddev)
        return images + noise
    return images

def time(f):
    @wraps(f)
    def _wrapped(*args, **kwargs):
        start = _timenow()
        result = f(*args, **kwargs)
        end = _timenow()
        print('[time] {}: {}'.format(f.__name__, end - start),
              file=stderr)
        return result

    return _wrapped


def split(samples, **kwargs):
    total = len(samples)
    indices = list(range(total))
    if kwargs['random']:
        np.random.shuffle(indices)
    percent = kwargs['split']
    # Split indices
    current = 0
    train_count = np.int(percent * total)
    train_indices = indices[current:current + train_count]
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```
        current += train_count
        test_indices = indices[current:]
        train_subset, test_subset = [], []
        for i in train_indices:
            train_subset.append(samples[i])

        for i in test_indices:
            test_subset.append(samples[i])
        return train_subset, test_subset

    def text_align(prWords, gtWords):
        row, col = len(prWords), len(gtWords)
        adjMat= np.zeros((row, col), dtype=float)
        for i in range(len(prWords)):
            for j in range(len(gtWords)):
                adjMat[i, j] = similarity(prWords[i], gtWords[j])
        pr_aligned=[]
        for i in range(len(prWords)):
            nn = list(map(lambda x:gtWords[x], np.argsort(adjMat[i, :])[:1]))
            pr_aligned.append((prWords[i], nn[0]))
        return pr_aligned

    class EarlyStopping:
        """Early stops the training if validation loss doesn't improve after a given patience."""
        def __init__(self, save_file, patience=5, verbose=False, delta=0, best_score=None):
            """
            Args:
                patience (int): How long to wait after last time validation loss improved.
                                Default: 7
                verbose (bool): If True, prints a message for each validation loss improvement.
                                Default: False
                delta (float): Minimum change in the monitored quantity to qualify as an improvement.
                                Default: 0
            """
            self.patience = patience
            self.verbose = verbose
            self.counter = 0
            self.best_score = best_score
            self.early_stop = False
            self.val_loss_min = np.Inf
            self.delta = delta
            self.save_file = save_file
            print(best_score)

        def __call__(self, val_loss, epoch, model, optimizer):

            score = -val_loss
            state = {
                    'epoch': epoch + 1,
                    'state_dict': model.state_dict(),
                    'opt_state_dict': optimizer.state_dict(),
                    'best': score
                    }
            if self.best_score is None:
                self.best_score = score
                self.save_checkpoint(val_loss, state)
            elif score < self.best_score - self.delta:

                self.counter += 1
                print(f'EarlyStopping counter: ({self.best_score:.6f} {self.counter} out of {self.patience})')
                if self.counter >= self.patience:
                    self.early_stop = True
            else:
                self.best_score = score
                self.save_checkpoint(val_loss, state)
                self.counter = 0

        def save_checkpoint(self, val_loss, state):
            '''Saves model when validation loss decrease.'''
            if self.verbose:
                print(f'Validation loss decreased ({self.val_loss_min:.6f} --> {val_loss:.6f}).  Saving model ...')
            torch.save(state, self.save_file)
            self.val_loss_min = val_loss


    class AverageMeter:
        def __init__(self, name):
            self.name = name
            self.count = 0
            self.total = 0
            self.max = -1 * float("inf")
            self.min = float("inf")
```

```
        def add(self, element):
            # pdb.set_trace()
            self.total += element
            self.count += 1
            self.max = max(self.max, element)
            self.min = min(self.min, element)

        def compute(self):
            # pdb.set_trace()
            if self.count == 0:
                return float("inf")
            return self.total / self.count

        def __str__(self):
            return "%s (min, avg, max): (%.3lf, %.3lf, %.3lf)" % (self.name, self.min, self.compute(), self.max)

    class Eval:
        def _blanks(self, max_vals,  max_indices):
            def get_ind(indices):
                result = []
                for i in range(len(indices)):
                    if indices[i] != 0:
                        result.append(i)
                return result
            non_blank = list(map(get_ind, max_indices))
            scores = []

            for i, sub_list in enumerate(non_blank):
                sub_val = []
                if sub_list:
                    for item in sub_list:
                        sub_val.append(max_vals[i][item])
                score = np.exp(np.sum(sub_val))
                if math.isnan(score):
                    score = 0.0
                scores.append(score)
            return scores


        def _clean(self, word):
            regex = re.compile('[%s]' % re.escape('!"#$%&\'()*+,-./:;<=>?@[\\]^_`{|}~“”„'))
            return regex.sub('', word)

        def char_accuracy(self, pair):
            words, truths = pair
            words, truths = ''.join(words), ''.join(truths)
            sum_edit_dists = lev.distance(words, truths)
            sum_gt_lengths = sum(map(len, truths))
            fraction = 0
            if sum_gt_lengths != 0:
                fraction = sum_edit_dists / sum_gt_lengths

            percent = fraction * 100
            if 100.0 - percent < 0:
                return 0.0
            else:
                return 100.0 - percent

        def word_accuracy(self, pair):
            correct = 0
            word, truth = pair
            if self._clean(word) == self._clean(truth):
                correct = 1
            return correct

        def format_target(self, target, target_sizes):
            target_ = []
            start = 0
            for size_ in target_sizes:
                target_.append(target[start:start + size_])
                start += size_
            return target_

        def word_accuracy_line(self, pairs):
            preds, truths = pairs
            word_pairs = text_align(preds.split(), truths.split())
            word_acc = np.mean((list(map(self.word_accuracy, word_pairs))))
            return word_acc

    class OCRLabelConverter(object):
        """Convert between str and label.
```

```
        NOTE:
            Insert `blank` to the alphabet for CTC.

        Args:
            alphabet (str): set of the possible characters.
            ignore_case (bool, default=True): whether or not to ignore all of the case.
        """

        def __init__(self, alphabet, ignore_case=False):
            self._ignore_case = ignore_case
            if self._ignore_case:
                alphabet = alphabet.lower()
            self.alphabet = alphabet + '-'  # for `-1` index

            self.dict = {}
            for i, char in enumerate(alphabet):
                # NOTE: 0 is reserved for 'blank' required by wrap_ctc
                self.dict[char] = i + 1
            self.dict[''] = 0
        def encode(self, text):
            """Support batch or single str.

            Args:
                text (str or list of str): texts to convert.

            Returns:
                torch.IntTensor [length_0 + length_1 + ... length_{n - 1}]: encoded texts.
                torch.IntTensor [n]: length of each text.
            """
            '''
            if isinstance(text, str):
                text = [
                    self.dict[char.lower() if self._ignore_case else char]
                    for char in text
                ]
                length = [len(text)]
            elif isinstance(text, collections.Iterable):
                length = [len(s) for s in text]
                text = ''.join(text)
                text, _ = self.encode(text)
            return (torch.IntTensor(text), torch.IntTensor(length))
            '''
            length = []
            result = []
            for item in text:
                # item = item.decode('utf-8', 'strict')
                length.append(len(item))
                for char in item:
                    if char in self.dict:
                        index = self.dict[char]
                    else:
                        index = 0
                    result.append(index)

            text = result
            return (torch.IntTensor(text), torch.IntTensor(length))

        def decode(self, t, length, raw=False):
            """Decode encoded texts back into strs.

            Args:
                torch.IntTensor [length_0 + length_1 + ... length_{n - 1}]: encoded texts.
                torch.IntTensor [n]: length of each text.

            Raises:
                AssertionError: when the texts and its length does not match.

            Returns:
                text (str or list of str): texts to convert.
            """
            if length.numel() == 1:
                length = length[0]
                assert t.numel() == length, "text with length: {} does not match declared length: {}".format(t.numel(),
                                                                                                             length)
                if raw:
                    return ''.join([self.alphabet[i - 1] for i in t])
                else:
                    char_list = []
                    for i in range(length):
                        if t[i] != 0 and (not (i > 0 and t[i - 1] == t[i])):
                            char_list.append(self.alphabet[t[i] - 1])
```

```
                return ''.join(char_list)
        else:
            # batch mode
            assert t.numel() == length.sum(), "texts with length: {} does not match declared length: {}".format(
                t.numel(), length.sum())
            texts = []
            index = 0
            for i in range(length.numel()):
                l = length[i]
                texts.append(
                    self.decode(t[index:index + l], torch.IntTensor([l]), raw=raw))
                index += l
            return texts
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Requirement already satisfied: textdistance in /usr/local/lib/python3.8/dist-packages (4.5.0)
```

```
import os
import sys
import pdb
import six
import random
import lmdb
from PIL import Image
import numpy as np
import math
from collections import OrderedDict
from itertools import chain
import logging
```

```
import torch
import torch.nn as nn
import torch.nn.functional as F
from torch.utils.data import Dataset
from torch.utils.data import sampler
from torch.optim.lr_scheduler import CosineAnnealingLR, StepLR
from torch.nn.utils.clip_grad import clip_grad_norm_
from torch.utils.data import random_split
sys.path.insert(0, '../')
from tqdm import *
```

Часть 1: Подготовка данных

```
# Подключаем диск
from google.colab import drive
drive.mount('/content/drive')

# Разархивируем картинки, предварительно загруженные на гугл-диск
!unzip /content/drive/MyDrive/CCPD2019-dl1.zip
```

```
# Пропишем класс для датасэтов

import os
import cv2
import torch
import torch.utils.data as data
import numpy as np

class PlateRecognitionDataset(data.Dataset):
    def __init__(self, root_dir, size=(64, 32)):
        self.root_dir = root_dir
        self.size = size
        self.images = []
        self.labels = []

        # Считываем картинки из директории
        for file_name in os.listdir(root_dir):
            file_path = os.path.join(root_dir, file_name)
            image = cv2.imread(file_path)
            image = cv2.resize(image, self.size)
            label = file_name.split('_')[0]
            self.images.append(np.transpose(image, (2, 0, 1))) #ndarray
            self.labels.append(label.split('-')[1].split('.')[0]) #str

    def __len__(self):
        return len(self.images)

    def __getitem__(self, idx):
```

```
            image = torch.from_numpy(np.array(self.images[idx])).cuda() # torch tensor
            label = self.labels[idx] # list of strings

            return {'img': image, 'label': label, 'idx': idx}




    class SynthCollator(object):

        def __call__(self, batch):
            width = [item['img'].shape[2] for item in batch]
            indexes = [item['idx'] for item in batch]
            imgs = torch.ones([len(batch), batch[0]['img'].shape[0], batch[0]['img'].shape[1],
                               max(width)], dtype=torch.float32).cuda()
            for idx, item in enumerate(batch):
                try:
                    imgs[idx, :, :, 0:item['img'].shape[2]] = item['img'].cuda()
                except:
                    print(imgs.shape)
            item = {'img': imgs, 'idx':indexes}
            if 'label' in batch[0].keys():
                labels = [item['label'] for item in batch]
                item['label'] = labels
            return item


    # # Тренировочный датасэт
    # train_dataset = PlateRecognitionDataset('/content/CCPD2019-dl1/train')
    # # Тестовый датасэт (он же в данном случае валидационный)
    # val_dataset = PlateRecognitionDataset('/content/CCPD2019-dl1/test')


    # # Нарисуем случайную кратинку

    # import matplotlib.pyplot as plt

    # # Выбираем рандомный индекс
    # idx = np.random.randint(0, len(train_dataset))
    # item = train_dataset[idx]

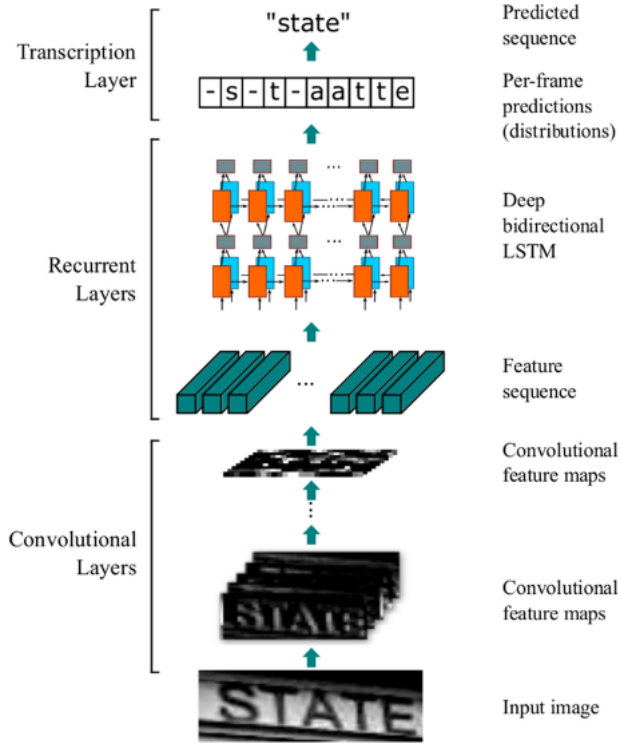
    # # Отображаем
    # image = item['img']
    # plt.imshow(image.cpu().detach().numpy())
    # plt.show()

    # # Ещё немного инфо
    # print(f'Всего {len(train_dataset)} картинок в train')
    # true_label = item['label']
    # print(f'Номер на этой картинке: {true_label}')


    # image.shape


    # # Токенизируем символы
    # s = ''
    # for num in train_dataset[:]['label']:
    #   s += num
    # all_tokens = list(set(s))
    # ''.join(all_tokens)
```

Часть 2: Создание и обучение модели




```
# Статья, в которой была предложена эта архитектура: https://arxiv.org/pdf/1507.05717.pdf
# Код по мотивам статьи: https://deepayan137.github.io/blog/markdown/2020/08/29/building-ocr.html


# Пропишем кастомный CTC лосс

import math

class CustomCTCLoss(torch.nn.Module):
    # T x B x H => Softmax on dimension 2
    def __init__(self, dim=2):
        super().__init__()
        self.dim = dim
        self.ctc_loss = torch.nn.CTCLoss(reduction='mean', zero_infinity=True)

    def forward(self, logits, labels,
            prediction_sizes, target_sizes):
        EPS = 1e-7
        loss = self.ctc_loss(logits, labels, prediction_sizes, target_sizes)
        loss = self.sanitize(loss)
        return self.debug(loss, logits, labels, prediction_sizes, target_sizes)

    def sanitize(self, loss):
        EPS = 1e-7
        if abs(loss.item() - float('inf')) < EPS:
            return torch.zeros_like(loss)
        if math.isnan(loss.item()):
            return torch.zeros_like(loss)
        return loss

    def debug(self, loss, logits, labels,
            prediction_sizes, target_sizes):
        if math.isnan(loss.item()):
            print("Loss:", loss)
            print("logits:", logits)
            print("labels:", labels)
            print("prediction_sizes:", prediction_sizes)
            print("target_sizes:", target_sizes)
            raise Exception("NaN loss obtained. But why?")
        return loss


# Модель в Pytorch для распознавания текста на картинке

import torch
import torch.nn as nn

class BidirectionalLSTM(nn.Module):

    def __init__(self, nIn, nHidden, nOut):
        super(BidirectionalLSTM, self).__init__()
        self.rnn = nn.LSTM(nIn, nHidden, bidirectional=True)
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```
            self.embedding = nn.Linear(nHidden * 2, nOut)
        def forward(self, input):
            self.rnn.flatten_parameters()
            recurrent, _ = self.rnn(input)
            T, b, h = recurrent.size()
            t_rec = recurrent.view(T * b, h)
            output = self.embedding(t_rec)  # [T * b, nOut]
            output = output.view(T, b, -1)
            return output

    class CRNN(nn.Module):

        def __init__(self, opt, leakyRelu=False):
            super(CRNN, self).__init__()

            assert opt['imgH'] % 16 == 0, 'imgH has to be a multiple of 16'

            ks = [3, 3, 3, 3, 3, 3, 2]
            ps = [1, 1, 1, 1, 1, 1, 0]
            ss = [1, 1, 1, 1, 1, 1, 1]
            nm = [64, 128, 256, 256, 512, 512, 512]

            cnn = nn.Sequential()

            def convRelu(i, batchNormalization=False):
                nIn = opt['nChannels'] if i == 0 else nm[i - 1]
                nOut = nm[i]
                cnn.add_module('conv{0}'.format(i),
                               nn.Conv2d(nIn, nOut, ks[i], ss[i], ps[i]))
                if batchNormalization:
                    cnn.add_module('batchnorm{0}'.format(i), nn.BatchNorm2d(nOut))
                if leakyRelu:
                    cnn.add_module('relu{0}'.format(i),
                                   nn.LeakyReLU(0.2, inplace=True))
                else:
                    cnn.add_module('relu{0}'.format(i), nn.ReLU(True))

            convRelu(0)
            cnn.add_module('pooling{0}'.format(0), nn.MaxPool2d(2, 2))  # 64x16x64
            convRelu(1)
            cnn.add_module('pooling{0}'.format(1), nn.MaxPool2d(2, 2))  # 128x8x32
            convRelu(2, True)
            convRelu(3)
            cnn.add_module('pooling{0}'.format(2),
                           nn.MaxPool2d((2, 2), (2, 1), (0, 1)))  # 256x4x16
            convRelu(4, True)
            convRelu(5)
            cnn.add_module('pooling{0}'.format(3),
                           nn.MaxPool2d((2, 2), (2, 1), (0, 1)))  # 512x2x16
            convRelu(6, True)  # 512x1x16
            self.cnn = cnn
            self.rnn = nn.Sequential()
            self.rnn = nn.Sequential(
                BidirectionalLSTM(opt['nHidden']*2, opt['nHidden'], opt['nHidden']),
                BidirectionalLSTM(opt['nHidden'], opt['nHidden'], opt['nClasses']))


        def forward(self, input):
            # conv features
            conv = self.cnn(input)
            b, c, h, w = conv.size()
            assert h == 1, "the height of conv must be 1"
            conv = conv.squeeze(2)
            conv = conv.permute(2, 0, 1)  # [w, b, c]
            # rnn features
            output = self.rnn(conv)
            output = output.transpose(1,0) #Tbh to bth
            return output


    # Класс для обучения модели:


    class OCRTrainer(object):
        def __init__(self, opt):
            super(OCRTrainer, self).__init__()
            self.data_train = opt['data_train']
            self.data_val = opt['data_val']
            self.model = opt['model']
            self.criterion = opt['criterion']
            self.optimizer = opt['optimizer']
            self.schedule = opt['schedule']
```

```
        self.converter = OCRLabelConverter(opt['alphabet'])
        self.evaluator = Eval()
        print('Scheduling is {}'.format(self.schedule))
        self.scheduler = CosineAnnealingLR(self.optimizer, T_max=opt['epochs'])
        self.batch_size = opt['batch_size']
        self.count = opt['epoch']
        self.epochs = opt['epochs']
        self.cuda = opt['cuda']
        self.collate_fn = opt['collate_fn']
        self.init_meters()

    def init_meters(self):
        self.avgTrainLoss = AverageMeter("Train loss")
        self.avgTrainCharAccuracy = AverageMeter("Train Character Accuracy")
        self.avgTrainWordAccuracy = AverageMeter("Train Word Accuracy")
        self.avgValLoss = AverageMeter("Validation loss")
        self.avgValCharAccuracy = AverageMeter("Validation Character Accuracy")
        self.avgValWordAccuracy = AverageMeter("Validation Word Accuracy")

    def forward(self, x):
        logits = self.model(x)
        return logits.transpose(1, 0)

    def loss_fn(self, logits, targets, pred_sizes, target_sizes):
        loss = self.criterion(logits, targets, pred_sizes, target_sizes)
        return loss

    def step(self):
        self.max_grad_norm = 0.05
        clip_grad_norm_(self.model.parameters(), self.max_grad_norm)
        self.optimizer.step()

    def schedule_lr(self):
        if self.schedule:
            self.scheduler.step()

    def _run_batch(self, batch, report_accuracy=False, validation=False):
        input_, targets = batch['img'], batch['label']
        targets, lengths = self.converter.encode(targets)
        logits = self.forward(input_)
        logits = logits.contiguous().cpu()
        logits = torch.nn.functional.log_softmax(logits, 2)
        T, B, H = logits.size()
        pred_sizes = torch.LongTensor([T for i in range(B)])
        targets= targets.view(-1).contiguous()
        loss = self.loss_fn(logits, targets, pred_sizes, lengths)
        if report_accuracy:
            probs, preds = logits.max(2)
            preds = preds.transpose(1, 0).contiguous().view(-1)
            sim_preds = self.converter.decode(preds.data, pred_sizes.data, raw=False)
            ca = np.mean((list(map(self.evaluator.char_accuracy, list(zip(sim_preds, batch['label']))))))
            wa = np.mean((list(map(self.evaluator.word_accuracy, list(zip(sim_preds, batch['label']))))))
        return loss, ca, wa

    def run_epoch(self, validation=False):
        if not validation:
            loader = self.train_dataloader()
            pbar = tqdm(loader, desc='Epoch: [%d]/[%d] Training'%(self.count,
                self.epochs), leave=True)
            self.model.train()
        else:
            loader = self.val_dataloader()
            pbar = tqdm(loader, desc='Validating', leave=True)
            self.model.eval()
        outputs = []
        for batch_nb, batch in enumerate(pbar):
            if not validation:
                output = self.training_step(batch)
            else:
                output = self.validation_step(batch)
            pbar.set_postfix(output)
            outputs.append(output)
        self.schedule_lr()
        if not validation:
            result = self.train_end(outputs)
        else:
            result = self.validation_end(outputs)
        return result

    def training_step(self, batch):
        loss, ca, wa = self._run_batch(batch, report_accuracy=True)
        self.optimizer.zero_grad()
```

```
            loss.backward()
            self.step()
            output = OrderedDict({
                'loss': abs(loss.item()),
                'train_ca': ca.item(),
                'train_wa': wa.item()
                })
            return output

        def validation_step(self, batch):
            loss, ca, wa = self._run_batch(batch, report_accuracy=True, validation=True)
            output = OrderedDict({
                'val_loss': abs(loss.item()),
                'val_ca': ca.item(),
                'val_wa': wa.item()
                })
            return output

        def train_dataloader(self):
            # logging.info('training data loader called')
            loader = torch.utils.data.DataLoader(self.data_train,
                    batch_size=self.batch_size,
                    collate_fn=self.collate_fn,
                    shuffle=True)
            return loader

        def val_dataloader(self):
            # logging.info('val data loader called')
            loader = torch.utils.data.DataLoader(self.data_val,
                    batch_size=self.batch_size,
                    collate_fn=self.collate_fn)
            return loader

        def train_end(self, outputs):
            for output in outputs:
                self.avgTrainLoss.add(output['loss'])
                self.avgTrainCharAccuracy.add(output['train_ca'])
                self.avgTrainWordAccuracy.add(output['train_wa'])

            train_loss_mean = abs(self.avgTrainLoss.compute())
            train_ca_mean = self.avgTrainCharAccuracy.compute()
            train_wa_mean = self.avgTrainWordAccuracy.compute()

            result = {'train_loss': train_loss_mean, 'train_ca': train_ca_mean,
            'train_wa': train_wa_mean}
            # result = {'progress_bar': tqdm_dict, 'log': tqdm_dict, 'val_loss': train_loss_mean}
            return result

        def validation_end(self, outputs):
            for output in outputs:
                self.avgValLoss.add(output['val_loss'])
                self.avgValCharAccuracy.add(output['val_ca'])
                self.avgValWordAccuracy.add(output['val_wa'])

            val_loss_mean = abs(self.avgValLoss.compute())
            val_ca_mean = self.avgValCharAccuracy.compute()
            val_wa_mean = self.avgValWordAccuracy.compute()

            result = {'val_loss': val_loss_mean, 'val_ca': val_ca_mean,
            'val_wa': val_wa_mean}
            return result

    # Класс, который всё собирает вместе

    class Learner(object):
        def __init__(self, model, optimizer, savepath=None, resume=False):
            self.model = model
            self.optimizer = optimizer
            self.savepath = os.path.join(savepath, 'best.ckpt')
            self.cuda = torch.cuda.is_available()
            self.cuda_count = torch.cuda.device_count()
            if self.cuda:
                self.model = self.model.cuda()
            self.epoch = 0
            if self.cuda_count > 1:
                print("Let's use", torch.cuda.device_count(), "GPUs!")
                self.model = nn.DataParallel(self.model)
            self.best_score = None
            if resume and os.path.exists(self.savepath):
                self.checkpoint = torch.load(self.savepath)
                self.epoch = self.checkpoint['epoch']
                self.best_score=self.checkpoint['best']
```

```
            self.load()
        else:
            print('checkpoint does not exist')

    def fit(self, opt):
        opt['cuda'] = self.cuda
        opt['model'] = self.model
        opt['optimizer'] = self.optimizer
        logging.basicConfig(filename="%s/%s.csv" %(opt['log_dir'], opt['name']), level=logging.INFO)
        self.saver = EarlyStopping(self.savepath, patience=15, verbose=True, best_score=self.best_score)
        opt['epoch'] = self.epoch
        trainer = OCRTrainer(opt)

        for epoch in range(opt['epoch'], opt['epochs']):
            train_result = trainer.run_epoch()
            val_result = trainer.run_epoch(validation=True)
            trainer.count = epoch
            info = '%d, %.6f, %.6f, %.6f, %.6f, %.6f, %.6f'%(epoch, train_result['train_loss'],
                val_result['val_loss'], train_result['train_ca'],  val_result['val_ca'],
                train_result['train_wa'], val_result['val_wa'])
            logging.info(info)
            self.val_loss = val_result['val_loss']
            print(self.val_loss)
            if self.savepath:
                self.save(epoch)
            if self.saver.early_stop:
                print("Early stopping")
                break

    def load(self):
        print('Loading checkpoint at {} trained for {} epochs'.format(self.savepath, self.checkpoint['epoch']))
        self.model.load_state_dict(self.checkpoint['state_dict'])
        if 'opt_state_dict' in self.checkpoint.keys():
            print('Loading optimizer')
            self.optimizer.load_state_dict(self.checkpoint['opt_state_dict'])

    def save(self, epoch):
        self.saver(self.val_loss, epoch, self.model, self.optimizer)
```

```
# Гиперпараметры

alphabet = """ XKR4浙09宁P皖豫贵鲁C粤蒙桂沪6L琼藏2京HB辽ODU云3J5S陕8赣青黑甘FZW川新AEQ渝VG冀吉Y7NT湘晋1苏鄂闽M津"""
args = {
    'name':'exp1',
    'path':'/content/CCPD2019-dl1/',
    'imgdir': 'train',
    'imgH':32,
    'nChannels':3,
    'nHidden':256,
    'nClasses':len(alphabet),
    'lr':0.001,
    'epochs':3,
    'batch_size':32,
    'save_dir':'/checkpoints/',
    'log_dir':'/logs',
    'resume':False,
    'cuda':False,
    'schedule':False

}

data = PlateRecognitionDataset('/content/CCPD2019-dl1/train')
args['collate_fn'] = SynthCollator()
train_split = int(0.8*len(data))
val_split = len(data) - train_split
args['data_train'], args['data_val'] = random_split(data, (train_split, val_split))
print('Traininig Data Size:{}\nVal Data Size:{}'.format(
    len(args['data_train']), len(args['data_val'])))
args['alphabet'] = alphabet
model = CRNN(args)
args['criterion'] = CustomCTCLoss()
savepath = os.path.join(args['save_dir'], args['name'])
gmkdir(savepath)
gmkdir(args['log_dir'])
optimizer = torch.optim.Adam(model.parameters(), lr=args['lr'])
learner = Learner(model, optimizer, savepath=savepath, resume=args['resume'])
learner.fit(args)
```

```
 Traininig Data Size:159984
 Val Data Size:39996
 checkpoint does not exist
 None
```

```
Scheduling is False
Epoch: [0]/[3] Training: 100%|██████████| 5000/5000 [02:58<00:00, 27.98it/s, loss=0.000391, train_ca=100, train_wa=1]
Validating: 100%|██████████| 1250/1250 [00:28<00:00, 44.22it/s, val_loss=0.00872, val_ca=100, val_wa=1]
0.024427342741168104
Validation loss decreased (inf --> 0.024427).  Saving model ...
Epoch: [0]/[3] Training: 100%|██████████| 5000/5000 [02:55<00:00, 28.42it/s, loss=0.000459, train_ca=100, train_wa=1]
Validating: 100%|██████████| 1250/1250 [00:26<00:00, 46.40it/s, val_loss=0.000554, val_ca=100, val_wa=1]
0.02089293116753979
Validation loss decreased (0.024427 --> 0.020893).  Saving model ...
Epoch: [1]/[3] Training: 100%|██████████| 5000/5000 [02:55<00:00, 28.45it/s, loss=0.0108, train_ca=99.1, train_wa=0.938]
Validating: 100%|██████████| 1250/1250 [00:26<00:00, 47.10it/s, val_loss=0.000162, val_ca=100, val_wa=1]
0.01903909787896458
Validation loss decreased (0.020893 --> 0.019039).  Saving model ...
```

Часть 3: Оценка качества

```
import matplotlib.pyplot as plt
from torchvision.utils import make_grid


device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
def get_accuracy(args):
    loader = torch.utils.data.DataLoader(args['data'],
                batch_size=args['batch_size'],
                collate_fn=args['collate_fn'])
    model = args['model']
    model.eval()
    converter = OCRLabelConverter(args['alphabet'])
    evaluator = Eval()
    labels, predictions, images = [], [], []
    for iteration, batch in enumerate(tqdm(loader)):
        input_, targets = batch['img'].to(device), batch['label']
        images.extend(input_.squeeze().detach())
        labels.extend(targets)
        targets, lengths = converter.encode(targets)
        logits = model(input_).transpose(1, 0)
        logits = torch.nn.functional.log_softmax(logits, 2)
        logits = logits.contiguous().cpu()
        T, B, H = logits.size()
        pred_sizes = torch.LongTensor([T for i in range(B)])
        probs, pos = logits.max(2)
        pos = pos.transpose(1, 0).contiguous().view(-1)
        sim_preds = converter.decode(pos.data, pred_sizes.data, raw=False)
        predictions.extend(sim_preds)

#     make_grid(images[:10], nrow=2)
    fig=plt.figure(figsize=(8, 8))
    columns = 4
    rows = 5
    pairs = list(zip(images, predictions))
    indices = np.random.permutation(len(pairs))
    for i in range(1, columns*rows +1):
        img = images[indices[i]]
        img = (img - img.min())/(img.max() - img.min())
        img = np.array(img.cpu() * 255.0, dtype=np.uint8)
        fig.add_subplot(rows, columns, i)
        plt.title(predictions[indices[i]])
        plt.axis('off')
        plt.imshow(np.transpose(img, (1, 2, 0)))
    plt.show()
    ca = np.mean((list(map(evaluator.char_accuracy, list(zip(predictions, labels))))))
    wa = np.mean((list(map(evaluator.word_accuracy_line, list(zip(predictions, labels))))))
    return ca, wa



args['imgdir'] = 'test'
args['data'] = PlateRecognitionDataset('/content/CCPD2019-dl1/test')
resume_file = os.path.join(args['save_dir'], args['name'], 'best.ckpt')
if os.path.isfile(resume_file):
    print('Loading model %s'%resume_file)
    checkpoint = torch.load(resume_file)
    model.load_state_dict(checkpoint['state_dict'])
    args['model'] = model
    ca, wa = get_accuracy(args)
    print("Character Accuracy: %.2f\nWord Accuracy: %.2f"%(ca, wa))
else:
    print('Exiting')
```

```
Loading model /checkpoints/exp1/best.ckpt
100%|██████████| 313/313 [00:05<00:00, 61.68it/s]
/usr/local/lib/python3.8/dist-packages/matplotlib/backends/backend_agg.py:214: Runtim
  font.set_text(s, 0.0, flags=flags)
/usr/local/lib/python3.8/dist-packages/matplotlib/backends/backend_agg.py:214: Runtim
  font.set_text(s, 0.0, flags=flags)
/usr/local/lib/python3.8/dist-packages/matplotlib/backends/backend_agg.py:183: Runtim
  font.set_text(s, 0, flags=flags)
/usr/local/lib/python3.8/dist-packages/matplotlib/backends/backend_agg.py:183: Runtim
  font.set_text(s, 0, flags=flags)
```


```
Character Accuracy: 98.98
```

✓ 15 сек. выполнено в 13:55