```
import itertools
from IPython.display import clear_output

import torchvision.transforms as transforms
from torch.utils.data import DataLoader
from PIL import Image
from skimage import io, transform
import torch
import torch.nn as nn
import torch.nn.functional as F
from pathlib import Path
import pathlib


import random
import time
import datetime
import sys

import torch
import numpy as np

import os
import random
import torch.backends.cudnn as cudnn
import torch.optim as optim
from torch.utils.data import Dataset, DataLoader
import torchvision.datasets as dset
import torchvision.transforms as transforms
import torchvision.utils as vutils
import numpy as np
import matplotlib.pyplot as plt
from IPython.display import HTML
```

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

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6

Enter your authorization code:
··········
Mounted at /content/drive
```

```
!unzip -q /content/drive/My\ Drive/monet2photo.zip -d data
```

```
!ls data/monet2photo
```

```
testA  testB  trainA  trainB
```

```
def imshow_(image: torch.Tensor):
    """ image rendering function"""
    img = np.transpose(vutils.make_grid(image.detach(), normalize=True).cpu().numpy(), (1, 2, 0))
    plt.imshow(img)
```

```
class utils():
    def __init__(self):
        pass

    @staticmethod
    def weights_init_normal(m):
        classname = m.__class__.__name__
        if classname.find('Conv') != -1:
            torch.nn.init.normal(m.weight.data, 0.0, 0.02)
        elif classname.find('BatchNorm2d') != -1:
            torch.nn.init.normal(m.weight.data, 1.0, 0.02)
            torch.nn.init.constant(m.bias.data, 0.0)

    @staticmethod
    def copy_(data):
        max_size = 50
        array = []
        to_return = []
        for element in data.data:
            element = torch.unsqueeze(element, 0)
            if len(array) < max_size:
                array.append(element)
                to_return.append(element)
            else:
                if random.uniform(0,1) > 0.5:
                    i = random.randint(0, max_size-1)
                    to_return.append(array[i].clone())
                    array[i] = element
                else:
                    to_return.append(element)
        return torch.cat(to_return)
```

```
class Storage():
    def __init__(self, arg):
        self.arg = arg


    def __getattr__(self, key):
        return self.arg[key]
```

```
storage = Storage({
    'lr': 0.00005,
    'n_epoch': 1000,
    'size_image': 512,
    'device': torch.device('cuda'),
    'batch_size': 1,
    'relevance_identify': 6,
    'relevance_cycle': 10,
})
```

```
class MyDataset(Dataset):

    def __init__(self, files, root_dir, transform=None):
        self.files = files
        self.root_dir = root_dir
        self.transform = transform
```

```
    def __len__(self):
        return len(self.files)

    def __getitem__(self, idx):
        if torch.is_tensor(idx):
            idx = idx.tolist()

        image = io.imread(self.files[idx])

        if self.transform:
            image = self.transform(image)

        return image
```

```
class ResidualBlock(nn.Module):
    def __init__(self, in_features):
        super(ResidualBlock, self).__init__()

        conv_block = [  nn.ReflectionPad2d(1),
                        nn.Conv2d(in_features, in_features, 3),
                        nn.InstanceNorm2d(in_features),
                        nn.ReLU(inplace=True),
                        nn.ReflectionPad2d(1),
                        nn.Conv2d(in_features, in_features, 3),
                        nn.InstanceNorm2d(in_features)  ]

        self.conv_block = nn.Sequential(*conv_block)

    def forward(self, x):
        return x + self.conv_block(x)

class Generator(nn.Module):
    def __init__(self, n_residual_blocks=9):
        super(Generator, self).__init__()

        # Initial convolution block
        model = [   nn.ReflectionPad2d(3),
                    nn.Conv2d(3, 64, 7),
                    nn.InstanceNorm2d(64),
                    nn.ReLU(inplace=True) ]

        # Downsampling
        in_features = 64
        out_features = in_features*2
        for _ in range(2):
            model += [  nn.Conv2d(in_features, out_features, 3, stride=2, padding=1),
                        nn.InstanceNorm2d(out_features),
                        nn.ReLU(inplace=True) ]
            in_features = out_features
            out_features = in_features*2

        # Residual blocks
        for _ in range(n_residual_blocks):
            model += [ResidualBlock(in_features)]

        # Upsampling
        out_features = in_features//2
        for _ in range(2):
```

```
            model += [  nn.ConvTranspose2d(in_features, out_features, 3, stride=2, padding=1, output
                        nn.InstanceNorm2d(out_features),
                        nn.ReLU(inplace=True) ]
            in_features = out_features
            out_features = in_features//2

        # Output layer
        model += [  nn.ReflectionPad2d(3),
                    nn.Conv2d(64, 3, 7),
                    nn.Tanh() ]

        self.model = nn.Sequential(*model)

    def forward(self, x):
        return self.model(x)

class Discriminator(nn.Module):
    def __init__(self):
        super(Discriminator, self).__init__()

        # A bunch of convolutions one after another
        model = [   nn.Conv2d(3, 64, 4, stride=2, padding=1),
                    nn.LeakyReLU(0.2, inplace=True) ]

        model += [  nn.Conv2d(64, 128, 4, stride=2, padding=1),
                    nn.InstanceNorm2d(128),
                    nn.LeakyReLU(0.2, inplace=True) ]

        model += [  nn.Conv2d(128, 256, 4, stride=2, padding=1),
                    nn.InstanceNorm2d(256),
                    nn.LeakyReLU(0.2, inplace=True) ]

        model += [  nn.Conv2d(256, 512, 4, padding=1),
                    nn.InstanceNorm2d(512),
                    nn.LeakyReLU(0.2, inplace=True) ]

        # FCN classification layer
        model += [nn.Conv2d(512, 1, 4, padding=1)]

        self.model = nn.Sequential(*model)

    def forward(self, x):
        x =  self.model(x)
        # Average pooling and flatten
        return F.avg_pool2d(x, x.size()[2:]).view(x.size()[0], -1)
```

```
TRAIN_DIR_A = Path('data/monet2photo/trainA')
TRAIN_DIR_B = Path('data/monet2photo/trainB')

list_name_a = sorted(list(TRAIN_DIR_A.rglob('*.jpg')))
list_name_b = sorted(list(TRAIN_DIR_B.rglob('*.jpg')))
```

```
transform = transforms.Compose([
            transforms.ToPILImage(),
            transforms.Resize((storage.size_image, storage.size_image)),
            transforms.ToTensor(),
            transforms.Normalize([0.5, 0.5, 0.5], [0.5, 0.5, 0.5])
])
```

```
dataset_a = MyDataset(list_name_a, 'data/dataset/A', transform)
dataset_b = MyDataset(list_name_b, 'data/dataset/B', transform)

dataloader_a = DataLoader(dataset_a, batch_size=storage.batch_size, shuffle=True)
dataloader_b = DataLoader(dataset_b, batch_size=storage.batch_size, shuffle=True)
# содание даталоадеров
```

```
from torchvision.models import resnet18
from torchsummary import summary
```

```
dis_a = Discriminator().cuda()
dis_b = Discriminator().cuda()
gen_ab = Generator().cuda()
gen_ba = Generator().cuda()

dis_a.apply(utils.weights_init_normal)
dis_b.apply(utils.weights_init_normal)
gen_ab.apply(utils.weights_init_normal)
gen_ba.apply(utils.weights_init_normal);
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:9: UserWarning: nn.init.normal is
  if __name__ == '__main__':
```

```
dis_a.load_state_dict(torch.load('/content/drive/My Drive/dis_a80.pth'))
dis_b.load_state_dict(torch.load('/content/drive/My Drive/dis_b80.pth'))
gen_ab.load_state_dict(torch.load('/content/drive/My Drive/gen_ab80.pth'))
gen_ba.load_state_dict(torch.load('/content/drive/My Drive/gen_ba80.pth'))
```

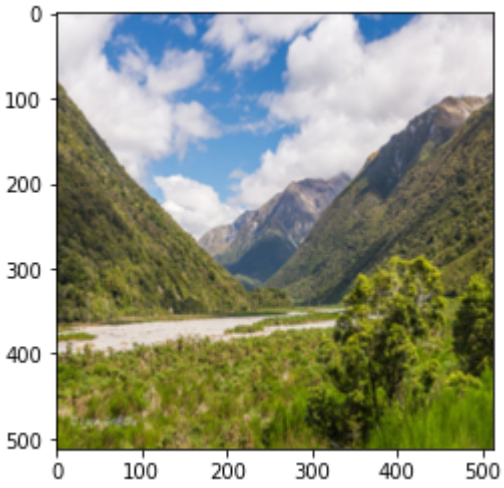
```
<All keys matched successfully>
```

```
opt_g = torch.optim.Adam(itertools.chain(gen_ab.parameters(), gen_ba.parameters()),
                                 lr=storage.lr, betas=(0.5, 0.999))
opt_d_b = torch.optim.Adam(dis_b.parameters(), lr=storage.lr, betas=(0.5, 0.999))
opt_d_a = torch.optim.Adam(dis_a.parameters(), lr=storage.lr, betas=(0.5, 0.999))
```

```
GAN_loss_fn = torch.nn.MSELoss()
cycle_and_identity_loss_fn = torch.nn.L1Loss()
```

```
sched_g = torch.optim.lr_scheduler.StepLR(opt_g, 200, 0.1)
sched_d_ba = torch.optim.lr_scheduler.StepLR(opt_d_b, 200, 0.1)
sched_d_ab = torch.optim.lr_scheduler.StepLR(opt_d_a, 200, 0.1)
```

```
for i in dataloader_b:
    imshow_(i)
    plt.show()
    imshow_(gen_ba(i.cuda()))
    break
```



Изначально я учил 130 эпох с шагом 0.0002 на картинках 256x256. Потом 23 эпохи с шагом 0.0005 на картинках 512x512

```
for epoch in range(storage.n_epoch):
    for i, (real_a, real_b) in enumerate(zip(dataloader_a, dataloader_b)):
        real_a, real_b = real_a.to(storage.device), real_b.to(storage.device)

        """ Generator"""
        opt_g.zero_grad()

        # 1 Identify loss
        same_a = gen_ba(real_a)
        same_b = gen_ab(real_b)
        identify_loss = (cycle_and_identity_loss_fn(same_b, real_b) + cycle_and_identity_loss_fn(sam

        # 2 Loss
        fake_a = gen_ba(real_b)
        fake_b = gen_ab(real_a)

        output_d_a = dis_a(fake_a)
        output_d_b = dis_b(fake_b)

        label = torch.full((real_a.size(0),), 1, device=storage.device)

        d_a_loss = GAN_loss_fn(output_d_a, label)
        d_b_loss = GAN_loss_fn(output_d_b, label)

        # 3 Cycle loss
        rec_a = gen_ba(fake_b)
        rec_b = gen_ab(fake_a)

        cycle_loss_a = cycle_and_identity_loss_fn(rec_a, real_a) * storage.relevance_cycle
        cycle_loss_b = cycle_and_identity_loss_fn(rec_b, real_b) * storage.relevance_cycle

        # 4 Backward
```

```
    loss_gen = identify_loss + d_a_loss + d_b_loss + cycle_loss_a + cycle_loss_b
    loss_gen.backward()

    opt_g.step()
    """ Discriminator"""
    opt_d_a.zero_grad()
    opt_d_b.zero_grad()

    # 1
    output_d_a = dis_a(real_a)
    output_d_b = dis_b(real_b)

    label = torch.full((output_d_a.size(0),), 1, device=storage.device)
    loss_d_a = GAN_loss_fn(output_d_a, label)
    loss_d_b = GAN_loss_fn(output_d_b, label)

    # 2
    fake_a = utils.copy_(fake_a)
    fake_b = utils.copy_(fake_b)

    output_d_a = dis_a(fake_a.detach())
    output_d_b = dis_b(fake_b.detach())

    label = torch.full((output_d_a.size(0),), 0, device=storage.device)
    loss_d_a_f = GAN_loss_fn(output_d_a, label)
    loss_d_b_f = GAN_loss_fn(output_d_b, label)

    # 3
    loss_dis_a = loss_d_a_f * 0.6 + loss_d_a * 0.7
    loss_dis_b = loss_d_b_f * 0.6 + loss_d_b * 0.7

    loss_dis_a.backward()
    loss_dis_b.backward()

    opt_d_a.step()
    opt_d_b.step()

    if i % 10 == 0: print('Epoch: {} \t num_iter: {} \t G_loss: {} \t D_loss: {}'.format(epoch,

clear_output(wait=True)
sched_g.step()
sched_d_ba.step()
sched_d_ab.step()

plt.figure(figsize=(15, 15))
plt.subplot(3, 2, 1)
imshow_(real_a[0])
plt.title('Real')
plt.axis('off')

plt.subplot(3, 2, 3)
imshow_(fake_b[0])
plt.title('Fake')
plt.axis('off')

plt.subplot(3, 2, 5)
imshow_(rec_a[0])
plt.title('Rec')
plt.axis('off')
```

```
    plt.axis('off')

    plt.subplot(3, 2, 2)
    imshow_(real_b[0])
    plt.title('Real')
    plt.axis('off')

    plt.subplot(3, 2, 4)
    imshow_(fake_a[0])
    plt.title('Fake')
    plt.axis('off')

    plt.subplot(3, 2, 6)
    imshow_(rec_b[0])
    plt.title('Rec')
    plt.axis('off')
    plt.show()

    if epoch % 5 == 0:
        torch.save(gen_ab.state_dict(), '/content/drive/My Drive/gen_ab{}.pth'.format(epoch))
        torch.save(gen_ba.state_dict(), '/content/drive/My Drive/gen_ba{}.pth'.format(epoch))
        torch.save(dis_a.state_dict(), '/content/drive/My Drive/dis_a{}.pth'.format(epoch))
        torch.save(dis_b.state_dict(), '/content/drive/My Drive/dis_b{}.pth'.format(epoch))
```

Real

Real

Fake

Fake

Rec

Rec

```
Epoch: 23        num_iter: 0     G_loss: 5.500554084777832       D_loss: 0.39735399186611176
Epoch: 23        num_iter: 10    G_loss: 5.127292633056641       D_loss: 0.3547002822160721
Epoch: 23        num_iter: 20    G_loss: 4.775240898132324       D_loss: 0.2236381284892559
Epoch: 23        num_iter: 30    G_loss: 6.060397624969482       D_loss: 0.660402700304985
Epoch: 23        num_iter: 40    G_loss: 6.448462963104248       D_loss: 0.1458670198917389
Epoch: 23        num_iter: 50    G_loss: 4.326433181762695       D_loss: 0.8904937505722046
Epoch: 23        num_iter: 60    G_loss: 6.2956109046936035      D_loss: 0.15741697512567043
Epoch: 23        num_iter: 70    G_loss: 6.779110908508301       D_loss: 0.2597932144999504
Epoch: 23        num_iter: 80    G_loss: 5.864455699920654       D_loss: 0.29854296147823334
Epoch: 23        num_iter: 90    G_loss: 5.739295959472656       D_loss: 0.32377202063798904
Epoch: 23        num_iter: 100   G_loss: 6.867908954620361       D_loss: 0.34206478483974934
Epoch: 23        num_iter: 110   G_loss: 8.633478164672852       D_loss: 0.5595912411808968
Epoch: 23        num_iter: 120   G_loss: 4.3680925369262695      D_loss: 0.42579007148742676
Epoch: 23        num_iter: 130   G_loss: 5.739649772644043       D_loss: 0.2048417292535305
Epoch: 23        num_iter: 140   G_loss: 7.389175891876221       D_loss: 0.18829447962343693
Epoch: 23        num_iter: 150   G_loss: 8.09268569946289        D_loss: 0.34050538018345833
```

```
Epoch: 23        num_iter: 160   G_loss: 5.426727771759033       D_loss: 0.36240212619304657
Epoch: 23        num_iter: 170   G_loss: 6.823221206665039       D_loss: 0.12648100778460503
Epoch: 23        num_iter: 180   G_loss: 6.355492115020752       D_loss: 0.2898993082344532
Epoch: 23        num_iter: 190   G_loss: 6.044657230377197       D_loss: 0.3383100628852844
Epoch: 23        num_iter: 200   G_loss: 5.221914291381836       D_loss: 0.5146136581897736
Epoch: 23        num_iter: 210   G_loss: 4.550348281860352       D_loss: 0.55864217877388
```

```
epoch = 23
torch.save(gen_ab.state_dict(), '/content/drive/My Drive/gen_ab{}.pth'.format(epoch))
torch.save(gen_ba.state_dict(), '/content/drive/My Drive/gen_ba{}.pth'.format(epoch))
torch.save(dis_a.state_dict(), '/content/drive/My Drive/dis_a{}.pth'.format(epoch))
torch.save(dis_b.state_dict(), '/content/drive/My Drive/dis_b{}.pth'.format(epoch))
```

```
Epoch: 23        num_iter: 380   G_loss: 5.555022239685059       D_loss: 0.24702979996800423
Epoch: 23        num_iter: 390   G_loss: 7.945556640625          D_loss: 0.13726626336574554
---------------------------------------------------------------------------
KeyboardInterrupt                         Traceback (most recent call last)
<ipython-input-73-5a702befa83d> in <module>()
     32         # 4 Backward
     33         loss_gen = identify_loss + d_a_loss + d_b_loss + cycle_loss_a + cycle_loss_b
---> 34         loss_gen.backward()
     35
     36         opt_g.step()

                                    1 frames
/usr/local/lib/python3.6/dist-packages/torch/autograd/__init__.py in backward(tensors, grad_te
     98     Variable._execution_engine.run_backward(
     99         tensors, grad_tensors, retain_graph, create_graph,
--> 100         allow_unreachable=True)  # allow_unreachable flag
    101
    102

KeyboardInterrupt:
```