```
%matplotlib inline

from PIL import Image
from io import BytesIO
import matplotlib.pyplot as plt
import numpy as np

import torch
import torch.optim as optim
import requests
from torchvision import transforms, models
```

```
vgg = models.vgg19(pretrained=True).features

# freeze all VGG parameters since we're only optimizing the target image
for param in vgg.parameters():
    param.requires_grad_(False)
```

```
Downloading: "https://download.pytorch.org/models/vgg19-dcbb9e9d.pth" to /roo
100%                                548M/548M [00:19<00:00, 29.9MB/s]
```

```
device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

vgg.to(device)
```

```
                  28 : 'conv5_1'}

    features = {}
    x = image
    # model._modules is a dictionary holding each module in the model
    for name, layer in model._modules.items():
        x = layer(x)
        if name in layers:
            features[layers[name]] = x

    return features
```

```
def gram_matrix(tensor):
    """ Calculate the Gram Matrix of a given tensor
        Gram Matrix: https://en.wikipedia.org/wiki/Gramian_matrix
    """

    # get the batch_size, depth, height, and width of the Tensor
    _, d, h, w = tensor.size()

    # reshape so we're multiplying the features for each channel
    tensor = tensor.view(d, h * w)

    # calculate the gram matrix
    gram = torch.mm(tensor, tensor.t())

    return gram
```

```
content_features = get_features(content, vgg)
style_features = get_features(style, vgg)

# calculate the gram matrices for each layer of our style representation
style_grams = {layer: gram_matrix(style_features[layer]) for layer in style_featur

# create a third "target" image and prep it for change
# it is a good idea to start off with the target as a copy of our *content* image
# then iteratively change its style
target = content.clone().requires_grad_(True).to(device)
```

```
style_weights = {'conv1_1': 1.,
                 'conv2_1': 0.75,
                 'conv3_1': 0.2,
                 'conv4_1': 0.2,
                 'conv5_1': 0.2}

content_weight = 1  # alpha
style_weight = 1e6  # beta
```

```
show_every = 400

# iteration hyperparameters
optimizer = optim.Adam([target], lr=0.003)
```

```
steps = 2000  # decide how many iterations to update your image (5000)

for ii in range(1, steps+1):

    # get the features from your target image
    target_features = get_features(target, vgg)

    # the content loss
    content_loss = torch.mean((target_features['conv4_2'] - content_features['conv

    # the style loss
    # initialize the style loss to 0
    style_loss = 0
    # then add to it for each layer's gram matrix loss
    for layer in style_weights:
        # get the "target" style representation for the layer
        target_feature = target_features[layer]
        target_gram = gram_matrix(target_feature)
        _, d, h, w = target_feature.shape
        # get the "style" style representation
        style_gram = style_grams[layer]
        # the style loss for one layer, weighted appropriately
        layer_style_loss = style_weights[layer] * torch.mean((target_gram - style_
        # add to the style loss
        style_loss += layer_style_loss / (d * h * w)

    # calculate the *total* loss
    total_loss = content_weight * content_loss + style_weight * style_loss

    # update your target image
    optimizer.zero_grad()
    total_loss.backward()
    optimizer.step()

    # display intermediate images and print the loss
    if  ii % show_every == 0:
        print('Total loss: ', total_loss.item())
        plt.imshow(im_convert(target))
        plt.show()
```

```
 Sequential(
   (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
   (1): ReLU(inplace=True)
   (2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
   (3): ReLU(inplace=True)
   (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=Fa
   (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
   (6): ReLU(inplace=True)
   (7): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
   (8): ReLU(inplace=True)
   (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=Fa
   (10): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
   (11): ReLU(inplace=True)
```

```
def load_image(img_path, max_size=400, shape=None):
    ''' Load in and transform an image, making sure the image
       is <= 400 pixels in the x-y dims.'''
    if "http" in img_path:
        response = requests.get(img_path)
        image = Image.open(BytesIO(response.content)).convert('RGB')
    else:
        image = Image.open(img_path).convert('RGB')

    # large images will slow down processing
    if max(image.size) > max_size:
        size = max_size
    else:
        size = max(image.size)

    if shape is not None:
        size = shape

    in_transform = transforms.Compose([
                        transforms.Resize(size),
                        transforms.ToTensor(),
                        transforms.Normalize((0.485, 0.456, 0.406),
                                             (0.229, 0.224, 0.225))])

    # discard the transparent, alpha channel (that's the :3) and add the batch dim
    image = in_transform(image)[:3,:,:].unsqueeze(0)

    return image
```

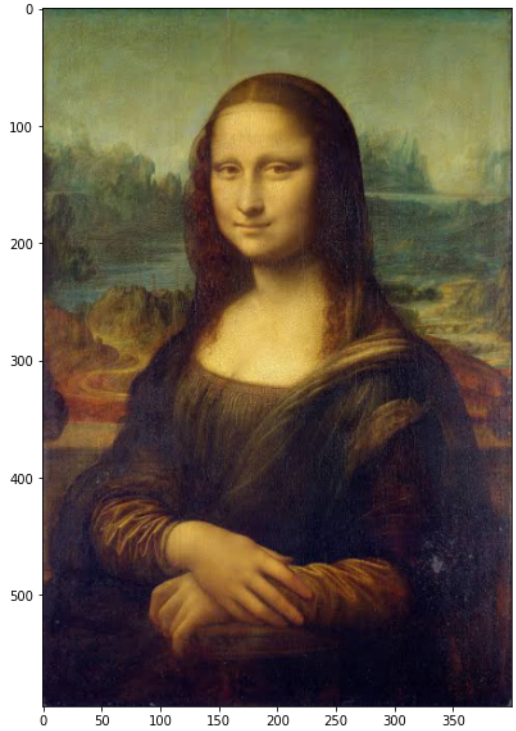
```
content = load_image('https://drive.google.com/uc?id=1SVALlBowh9oTxm0FOO1mw-njF3ha
# Resize style to match content, makes code easier
style = load_image('https://drive.google.com/uc?id=1F_2LlraF5CZihotB0DqqZbLhJfdp9n
```

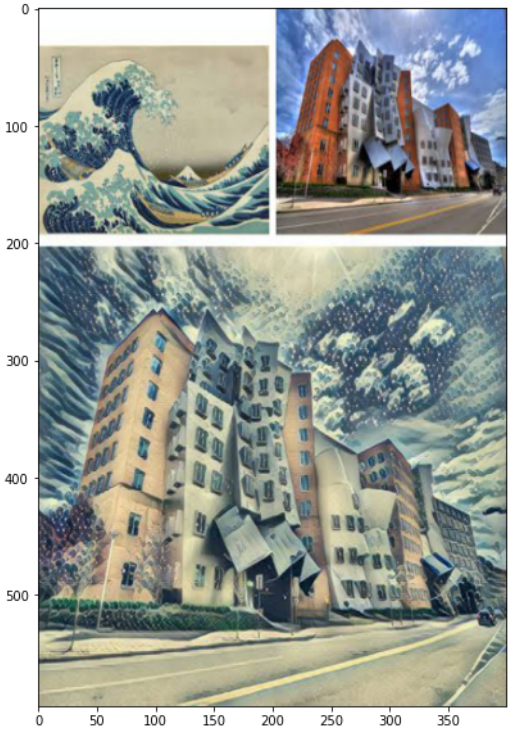
```
def im_convert(tensor):
    """ Display a tensor as an image. """

    image = tensor.to("cpu").clone().detach()
    image = image.numpy().squeeze()
    image = image.transpose(1,2,0)
    image = image * np.array((0.229, 0.224, 0.225)) + np.array((0.485, 0.456, 0.40
    image = image.clip(0, 1)
```

```
    return image
```

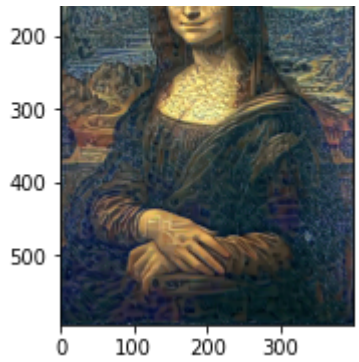
```
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(20, 10))
# content and style ims side-by-side
ax1.imshow(im_convert(content))
ax2.imshow(im_convert(style))
```

```
<matplotlib.image.AxesImage at 0x7f3d6809c9e8>
```

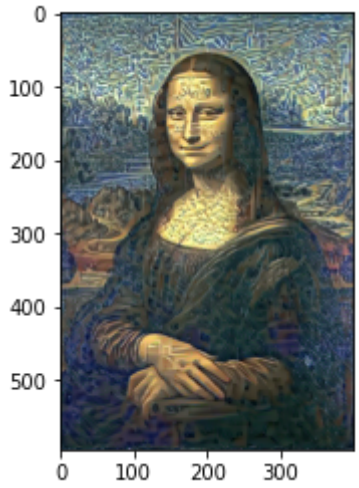




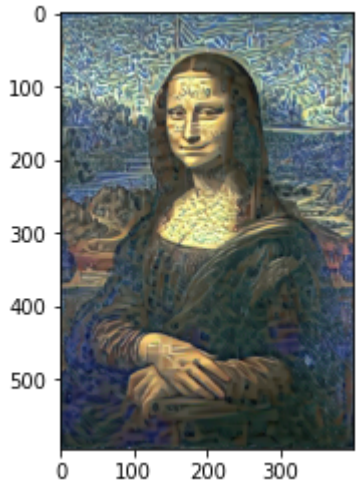

```
def get_features(image, model, layers=None):
    """ Run an image forward through a model and get the features for
        a set of layers. Default layers are for VGGNet matching Gatys et al (2016)
    """

    ## TODO: Complete mapping layer names of PyTorch's VGGNet to names from the pa
    ## Need the layers for the content and style representations of an image
    if layers is None:
        layers = {'0': 'conv1_1',
                  '5': 'conv2_1',
                  '10': 'conv3_1',
                  '19': 'conv4_1',
                  '21': 'conv4_2',  ## content representation
                  '28': 'conv5_1'}
```



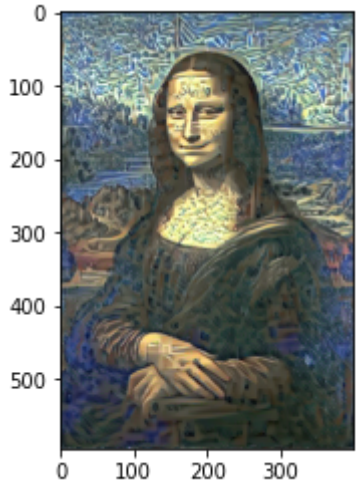

```
Total loss:  6261077.0
```




```
Total loss:  3943610.75
```




```
Total loss:  2645339.5
```



```
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(20, 10))
ax1.imshow(im_convert(content))
ax2.imshow(im_convert(target))
```

```
<matplotlib.image.AxesImage at 0x7f3d65142f28>
```