Neural Style Transfer

- Created for Understanding NST (Neural Style Transfer) and Creating Art with Keras & Colab.
- Used for a coursework (717303) at Hallym Univ.

```
!pwd
```

```
/content
```

```python
import os
#os.environ["CUDA_DEVICE_ORDER"]="PCI_BUS_ID"
#os.environ["CUDA_VISIBLE_DEVICES"]="{}".format(3) # gpu idx
```

```python
from __future__ import print_function
from keras.preprocessing.image import load_img, save_img, img_to_array
import numpy as np
from scipy.optimize import fmin_l_bfgs_b
import time
import argparse
import matplotlib.pyplot as plt
from keras.applications import vgg19
from keras import backend as K
```

```
Using TensorFlow backend.
```

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

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/co
```

```
!ls
```

```
'$'   drive   out   sample_data
```

- 아래와 같이 'AICapstone-2019Fall'을 만들었다고 가정합니다. (Google Drive)

```
!ls drive/'My Drive'/'Colab Notebooks'/AICapstone-2019Fall/images
```

```
20180904_161416.jpg  gogh_starry.jpg    monet_400x300.jpg
20181031_181602.jpg  louvre_small.jpg
```

```python
basedir = "/content/drive/My Drive/Colab Notebooks/AICapstone-2019Fall/"
print(basedir)
```

```
/content/drive/My Drive/Colab Notebooks/AICapstone-2019Fall/
```

```python
outDir = basedir+'/out'

import os
```

```
if not os.path.exists(outDir):
    os.makedirs(outDir)
    print('created...{}'.format(outDir))

#!ls "$outDir/../"
```

```
base_image_path = basedir+'images/20180904_161416.jpg'
style_reference_image_path = basedir+'images/monet_400x300.jpg'#gogh_starry

print(base_image_path)
print(style_reference_image_path )
```

> /content/drive/My Drive/Colab Notebooks/AICapstone-2019Fall/images/20180904_161416.jpg
> /content/drive/My Drive/Colab Notebooks/AICapstone-2019Fall/images/monet_400x300.jpg

▼ 설정

```
import datetime
str_time = datetime.datetime.now().strftime("%Y%m%d_%H%M%S")

#result_prefix = 'generated'
#result_prefix = 'pic1'
result_prefix = 'pic_'+str_time
print(result_prefix)
```

> pic_20191007_090756

```
iterations  = 100
```

```
content_weight = 0.025

style_weight = 1.0
#Total Variation weight.
total_variation_weight = 1.0
```
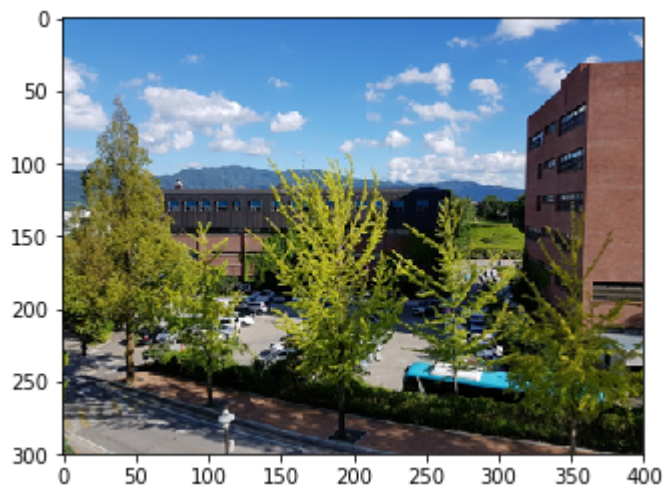
▼ 그림 불러와서 테스트

```
img1 = load_img(base_image_path, target_size=(300,400))
print(img1.size)
img2 = load_img(style_reference_image_path, target_size=(300,400))
print(img2.size)
```

> (400, 300)
> (400, 300)

```
imgplot = plt.imshow(img1)
```

>

```
imgplot = plt.imshow(img2)
```


The weights of the different loss components

▾ **Dimensions of the generated picture**

```
width, height = load_img(base_image_path).size
print(width, height)
```

```
400 300
```

```
img_nrows = 400
img_ncols = 300#int(width * img_nrows / height)
print(img_nrows, img_ncols)
```

```
400 300
```

▾ **Util functions**

```
#  to open, resize and format pictures into appropriate tensors
def preprocess_image(image_path):
```

```
    img = load_img(image_path, target_size=(img_nrows, img_ncols))
    img = img_to_array(img)
    img = np.expand_dims(img, axis=0)
    img = vgg19.preprocess_input(img)
    return img
```

```
def deprocess_image(x):
    if K.image_data_format() == 'channels_first':
        x = x.reshape((3, img_nrows, img_ncols))
        x = x.transpose((1, 2, 0))
    else:
        x = x.reshape((img_nrows, img_ncols, 3))
    # Remove zero-center by mean pixel
    x[:, :, 0] += 103.939
    x[:, :, 1] += 116.779
    x[:, :, 2] += 123.68
    # 'BGR'->'RGB'
    x = x[:, :, ::-1]
    x = np.clip(x, 0, 255).astype('uint8')
    return x
```

```
# get tensor representations of our images
base_image = K.variable(preprocess_image(base_image_path))
style_reference_image = K.variable(preprocess_image(style_reference_image_path))
```

```
K.image_data_format()
```

```
'channels_last'
```

```
# this will contain our generated image
if K.image_data_format() == 'channels_first':
    combination_image = K.placeholder((1, 3, img_nrows, img_ncols))
else:
    combination_image = K.placeholder((1, img_nrows, img_ncols, 3))
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backer
```

```
# combine the 3 images into a single Keras tensor
input_tensor = K.concatenate([base_image,
                              style_reference_image,
                              combination_image], axis=0)
```

▾ **build the VGG19 network**

```
# build the VGG19 network with our 3 images as input
# the model will be loaded with pre-trained ImageNet weights
model = vgg19.VGG19(input_tensor=input_tensor,
                    weights='imagenet', include_top=False)
print('Model loaded.')
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backer
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backer
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backer
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backer
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backer
Model loaded.
```

```python
# get the symbolic outputs of each "key" layer (we gave them unique names).
outputs_dict = dict([(layer.name, layer.output) for layer in model.layers])
```

▾ Compute the neural style loss

```python
# first we need to define 4 util functions
# the gram matrix of an image tensor (feature-wise outer product)

def gram_matrix(x):
    assert K.ndim(x) == 3
    if K.image_data_format() == 'channels_first':
        features = K.batch_flatten(x)
    else:
        features = K.batch_flatten(K.permute_dimensions(x, (2, 0, 1)))
    gram = K.dot(features, K.transpose(features))
    return gram
```

```python
# the "style loss" is designed to maintain
# the style of the reference image in the generated image.
# It is based on the gram matrices (which capture style) of
# feature maps from the style reference image
# and from the generated image
def style_loss(style, combination):
    assert K.ndim(style) == 3
    assert K.ndim(combination) == 3
    S = gram_matrix(style)
    C = gram_matrix(combination)
    channels = 3
    size = img_nrows * img_ncols
    return K.sum(K.square(S - C)) / (4.0 * (channels ** 2) * (size ** 2))
```

```python
# an auxiliary loss function
# designed to maintain the "content" of the
# base image in the generated image


def content_loss(base, combination):
    return K.sum(K.square(combination - base))
```

```python
# the 3rd loss function, total variation loss,
# designed to keep the generated image locally coherent

def total_variation_loss(x):
    assert K.ndim(x) == 4
    if K.image_data_format() == 'channels_first':
        a = K.square(
            x[:, :, :img_nrows - 1, :img_ncols - 1] - x[:, :, 1:, :img_ncols - 1])
        b = K.square(
            x[:, :, :img_nrows - 1, :img_ncols - 1] - x[:, :, :img_nrows - 1, 1:])
    else:
        a = K.square(
            x[:, :img_nrows - 1, :img_ncols - 1, :] - x[:, 1:, :img_ncols - 1, :])
        b = K.square(
            x[:, :img_nrows - 1, :img_ncols - 1, :] - x[:, :img_nrows - 1, 1:, :])
    return K.sum(K.pow(a + b, 1.25))
```

Combine these loss functions into a single scalar

```python
loss = K.variable(0.0)
layer_features = outputs_dict['block5_conv2']
base_image_features = layer_features[0, :, :, :]
combination_features = layer_features[2, :, :, :]
loss = loss + content_weight * content_loss(base_image_features,
                                            combination_features)
```

```python
feature_layers = ['block1_conv1', 'block2_conv1',
                  'block3_conv1', 'block4_conv1',
                  'block5_conv1']
```

```python
for layer_name in feature_layers:
    layer_features = outputs_dict[layer_name]
    style_reference_features = layer_features[1, :, :, :]
    combination_features = layer_features[2, :, :, :]
    sl = style_loss(style_reference_features, combination_features)
    loss = loss + (style_weight / len(feature_layers)) * sl
```

```python
loss = loss + total_variation_weight * total_variation_loss(combination_image)
```

```python
# get the gradients of the generated image wrt the loss
grads = K.gradients(loss, combination_image)
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow/python/ops/math_grad
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
```

```python
outputs = [loss]
if isinstance(grads, (list, tuple)):
    outputs += grads
else:
```

```
else:
    outputs.append(grads)
```

```
f_outputs = K.function([combination_image], outputs)
```

```python
def eval_loss_and_grads(x):
    if K.image_data_format() == 'channels_first':
        x = x.reshape((1, 3, img_nrows, img_ncols))
    else:
        x = x.reshape((1, img_nrows, img_ncols, 3))
    outs = f_outputs([x])
    loss_value = outs[0]
    if len(outs[1:]) == 1:
        grad_values = outs[1].flatten().astype('float64')
    else:
        grad_values = np.array(outs[1:]).flatten().astype('float64')
    return loss_value, grad_values
```

```python
# this Evaluator class makes it possible
# to compute loss and gradients in one pass
# while retrieving them via two separate functions,
# "loss" and "grads". This is done because scipy.optimize
# requires separate functions for loss and gradients,
# but computing them separately would be inefficient.


class Evaluator(object):

    def __init__(self):
        self.loss_value = None
        self.grads_values = None

    def loss(self, x):
        assert self.loss_value is None
        loss_value, grad_values = eval_loss_and_grads(x)
        self.loss_value = loss_value
        self.grad_values = grad_values
        return self.loss_value

    def grads(self, x):
        assert self.loss_value is not None
        grad_values = np.copy(self.grad_values)
        self.loss_value = None
        self.grad_values = None
        return grad_values


evaluator = Evaluator()
```

```
print(outDir)
```

```
/content/drive/My Drive/Colab Notebooks/out/
```

```
ls "$outDir"
```

```
!ls $outDir
```

pic_20191007_085341_at_iteration_0.png   pic_20191007_085341_at_iteration_5.png
pic_20191007_085341_at_iteration_10.png   pic_20191007_085341_at_iteration_6.png
pic_20191007_085341_at_iteration_11.png   pic_20191007_085341_at_iteration_7.png
pic_20191007_085341_at_iteration_12.png   pic_20191007_085341_at_iteration_8.png
pic_20191007_085341_at_iteration_13.png   pic_20191007_085341_at_iteration_9.png
pic_20191007_085341_at_iteration_14.png   pic2_at_iteration_0.png
pic_20191007_085341_at_iteration_15.png   pic2_at_iteration_10.png
pic_20191007_085341_at_iteration_16.png   pic2_at_iteration_11.png
pic_20191007_085341_at_iteration_17.png   pic2_at_iteration_12.png
pic_20191007_085341_at_iteration_18.png   pic2_at_iteration_13.png
pic_20191007_085341_at_iteration_19.png   pic2_at_iteration_14.png
pic_20191007_085341_at_iteration_1.png   pic2_at_iteration_15.png
pic_20191007_085341_at_iteration_20.png   pic2_at_iteration_16.png
pic_20191007_085341_at_iteration_21.png   pic2_at_iteration_17.png
pic_20191007_085341_at_iteration_22.png   pic2_at_iteration_18.png
pic_20191007_085341_at_iteration_23.png   pic2_at_iteration_1.png
pic_20191007_085341_at_iteration_24.png   pic2_at_iteration_2.png
pic_20191007_085341_at_iteration_25.png   pic2_at_iteration_3.png
pic_20191007_085341_at_iteration_26.png   pic2_at_iteration_4.png
pic_20191007_085341_at_iteration_27.png   pic2_at_iteration_5.png
pic_20191007_085341_at_iteration_28.png   pic2_at_iteration_6.png
pic_20191007_085341_at_iteration_29.png   pic2_at_iteration_7.png
pic_20191007_085341_at_iteration_2.png   pic2_at_iteration_8.png
pic_20191007_085341_at_iteration_3.png   pic2_at_iteration_9.png
pic_20191007_085341_at_iteration_4.png

```python
# run scipy-based optimization (L-BFGS) over the pixels of the generated image
# so as to minimize the neural style loss
x = preprocess_image(base_image_path)

for i in range(iterations):
    print('Start of iteration', i)
    start_time = time.time()
    x, min_val, info = fmin_l_bfgs_b(evaluator.loss, x.flatten(),
                                     fprime=evaluator.grads, maxfun=20)
    print('Current loss value:', min_val)
    # save current generated image
    img = deprocess_image(x.copy())
    fname = outDir + '/' + result_prefix + '_at_iteration_%d.png' % i
    #fname = '/content/drive/' + result_prefix + '_at_iteration_%d.png' % i

    #!ls "/content/drive/My Drive"

    #fname = '/content/drive/My Drive/Colab Notebooks/out/'+ result_prefix + '_at_iteration_%d.png'

    print(fname)
    save_img(fname, img)
    end_time = time.time()
    print('Image saved as', fname)
    print('Iteration %d completed in %ds' % (i, end_time - start_time))
```

```
Start of iteration 0
Current loss value: 1560207000.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_0.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_(
Iteration 0 completed in 12s
Start of iteration 1
Current loss value: 835884600.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_1.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 1 completed in 8s
Start of iteration 2
Current loss value: 635887740.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 2 completed in 8s
Start of iteration 3
Current loss value: 553888200.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 3 completed in 9s
Start of iteration 4
Current loss value: 508671600.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 4 completed in 8s
Start of iteration 5
Current loss value: 479060500.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 5 completed in 9s
Start of iteration 6
Current loss value: 452370460.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 6 completed in 9s
Start of iteration 7
Current loss value: 434575460.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 7 completed in 8s
Start of iteration 8
Current loss value: 420694200.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_8.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_8
Iteration 8 completed in 9s
Start of iteration 9
Current loss value: 410787170.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_9.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_9
Iteration 9 completed in 8s
Start of iteration 10
Current loss value: 402574270.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_10.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 10 completed in 8s
Start of iteration 11
Current loss value: 396013380.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_11.png
```

```
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_11.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 11 completed in 8s
Start of iteration 12
Current loss value: 389838000.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_12.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 12 completed in 8s
Start of iteration 13
Current loss value: 384090370.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_13.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 13 completed in 8s
Start of iteration 14
Current loss value: 379225150.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_14.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 14 completed in 8s
Start of iteration 15
Current loss value: 374931400.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_15.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 15 completed in 8s
Start of iteration 16
Current loss value: 370889340.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_16.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 16 completed in 8s
Start of iteration 17
Current loss value: 367293820.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_17.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 17 completed in 8s
Start of iteration 18
Current loss value: 363641470.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_18.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 18 completed in 8s
Start of iteration 19
Current loss value: 358342600.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_19.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_
Iteration 19 completed in 9s
Start of iteration 20
Current loss value: 353702000.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_20.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 20 completed in 9s
Start of iteration 21
Current loss value: 351007840.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_21.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 21 completed in 9s
Start of iteration 22
Current loss value: 348279600.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_22.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 22 completed in 9s
Start of iteration 23
```

```
Current loss value: 345565120.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_23.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 23 completed in 9s
Start of iteration 24
Current loss value: 343207650.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_24.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 24 completed in 9s
Start of iteration 25
Current loss value: 341041300.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_25.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 25 completed in 9s
Start of iteration 26
Current loss value: 338560700.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_26.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 26 completed in 9s
Start of iteration 27
Current loss value: 336482940.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_27.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 27 completed in 9s
Start of iteration 28
Current loss value: 334630600.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_28.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 28 completed in 9s
Start of iteration 29
Current loss value: 332423100.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_29.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_2
Iteration 29 completed in 9s
Start of iteration 30
Current loss value: 330661000.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_30.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 30 completed in 9s
Start of iteration 31
Current loss value: 329042180.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_31.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 31 completed in 9s
Start of iteration 32
Current loss value: 327628030.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_32.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 32 completed in 8s
Start of iteration 33
Current loss value: 326175500.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_33.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 33 completed in 8s
Start of iteration 34
Current loss value: 324467800.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_34.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
```

```
Iteration 34 completed in 9s
Start of iteration 35
Current loss value: 323012100.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_35.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 35 completed in 9s
Start of iteration 36
Current loss value: 321673800.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_36.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 36 completed in 9s
Start of iteration 37
Current loss value: 320389100.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_37.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 37 completed in 8s
Start of iteration 38
Current loss value: 318737280.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_38.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 38 completed in 9s
Start of iteration 39
Current loss value: 317285060.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_39.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_3
Iteration 39 completed in 8s
Start of iteration 40
Current loss value: 315480320.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_40.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 40 completed in 9s
Start of iteration 41
Current loss value: 314091550.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_41.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 41 completed in 8s
Start of iteration 42
Current loss value: 312795800.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_42.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 42 completed in 9s
Start of iteration 43
Current loss value: 311708900.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_43.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 43 completed in 9s
Start of iteration 44
Current loss value: 310687170.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_44.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 44 completed in 9s
Start of iteration 45
Current loss value: 309877600.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_45.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 45 completed in 9s
Start of iteration 46
Current loss value: 308748800.0
```

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/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_46.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 46 completed in 9s
Start of iteration 47
Current loss value: 307706620.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_47.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 47 completed in 8s
Start of iteration 48
Current loss value: 306627420.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_48.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 48 completed in 9s
Start of iteration 49
Current loss value: 305640400.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_49.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_4
Iteration 49 completed in 8s
Start of iteration 50
Current loss value: 304906780.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_50.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 50 completed in 9s
Start of iteration 51
Current loss value: 304091840.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_51.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 51 completed in 8s
Start of iteration 52
Current loss value: 303377180.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_52.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 52 completed in 8s
Start of iteration 53
Current loss value: 302422600.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_53.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 53 completed in 9s
Start of iteration 54
Current loss value: 301540860.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_54.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 54 completed in 8s
Start of iteration 55
Current loss value: 300776450.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 55 completed in 9s
Start of iteration 56
Current loss value: 300040640.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_56.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 56 completed in 8s
Start of iteration 57
Current loss value: 299253000.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_57.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 57 completed in 8s
```

```
Start of iteration 58
Current loss value: 298611200.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_58.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 58 completed in 8s
Start of iteration 59
Current loss value: 297806080.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_59.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_5
Iteration 59 completed in 8s
Start of iteration 60
Current loss value: 297031140.0
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Iteration 60 completed in 9s
Start of iteration 61
Current loss value: 296416160.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 61 completed in 8s
Start of iteration 62
Current loss value: 295846080.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 62 completed in 8s
Start of iteration 63
Current loss value: 295232350.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 63 completed in 8s
Start of iteration 64
Current loss value: 294627260.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 64 completed in 8s
Start of iteration 65
Current loss value: 294009500.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 65 completed in 8s
Start of iteration 66
Current loss value: 293457020.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 66 completed in 8s
Start of iteration 67
Current loss value: 292803650.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 67 completed in 8s
Start of iteration 68
Current loss value: 292182460.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_68.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 68 completed in 8s
Start of iteration 69
Current loss value: 291548640.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_69.png
```

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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_6
Iteration 69 completed in 8s
Start of iteration 70
Current loss value: 290985950.0
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Iteration 70 completed in 8s
Start of iteration 71
Current loss value: 290451970.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 71 completed in 8s
Start of iteration 72
Current loss value: 290010600.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 72 completed in 8s
Start of iteration 73
Current loss value: 289476380.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 73 completed in 8s
Start of iteration 74
Current loss value: 288988600.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 74 completed in 8s
Start of iteration 75
Current loss value: 288418240.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 75 completed in 9s
Start of iteration 76
Current loss value: 287970100.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 76 completed in 8s
Start of iteration 77
Current loss value: 287414530.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 77 completed in 8s
Start of iteration 78
Current loss value: 286940160.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_78.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 78 completed in 8s
Start of iteration 79
Current loss value: 286545470.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_79.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_7
Iteration 79 completed in 8s
Start of iteration 80
Current loss value: 286019330.0
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Iteration 80 completed in 8s
Start of iteration 81
Current loss value: 285537700.0
```

Current loss value: 285527700.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_81.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_8
Iteration 81 completed in 8s
Start of iteration 82
Current loss value: 285096400.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_82.png
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Iteration 82 completed in 8s
Start of iteration 83
Current loss value: 284627400.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_83.png
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Iteration 83 completed in 8s
Start of iteration 84
Current loss value: 284181100.0
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Iteration 84 completed in 8s
Start of iteration 85
Current loss value: 283795840.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_85.png
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Iteration 85 completed in 8s
Start of iteration 86
Current loss value: 283298600.0
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Iteration 86 completed in 8s
Start of iteration 87
Current loss value: 282693400.0
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Iteration 87 completed in 8s
Start of iteration 88
Current loss value: 282205060.0
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Iteration 88 completed in 9s
Start of iteration 89
Current loss value: 281810560.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_89.png
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Iteration 89 completed in 8s
Start of iteration 90
Current loss value: 281429060.0
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Iteration 90 completed in 8s
Start of iteration 91
Current loss value: 280995360.0
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Iteration 91 completed in 9s
Start of iteration 92
Current loss value: 280585340.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_9
Iteration 92 completed in 8s

```
Iteration 92 completed in 8s
Start of iteration 93
Current loss value: 279747620.0
/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_93.png
Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_9
Iteration 93 completed in 8s
Start of iteration 94
Current loss value: 278920900.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_9
Iteration 94 completed in 8s
Start of iteration 95
Current loss value: 278436200.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_9
Iteration 95 completed in 8s
Start of iteration 96
Current loss value: 278050720.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_9
Iteration 96 completed in 8s
Start of iteration 97
Current loss value: 277673020.0
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Image saved as /content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_9
Iteration 97 completed in 8s
```

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!ls "$outDir"
```

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pic_20191007_090756_at_iteration_33.png
pic_20191007_090756_at_iteration_34.png
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pic_20191007_090756_at_iteration_34.png
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pic_20191007_090756_at_iteration_80.png
pic_20191007_090756_at_iteration_81.png
pic_20191007_090756_at_iteration_82.png
pic_20191007_090756_at_iteration_83.png
pic_20191007_090756_at_iteration_84.png
pic_20191007_090756_at_iteration_85.png
pic_20191007_090756_at_iteration_86.png
pic_20191007_090756_at_iteration_87.png
```

```
pic_20191007_090756_at_iteration_88.png
pic_20191007_090756_at_iteration_89.png
pic_20191007_090756_at_iteration_8.png
pic_20191007_090756_at_iteration_90.png
pic_20191007_090756_at_iteration_91.png
pic_20191007_090756_at_iteration_92.png
pic_20191007_090756_at_iteration_93.png
pic_20191007_090756_at_iteration_94.png
pic_20191007_090756_at_iteration_95.png
pic_20191007_090756_at_iteration_96.png
pic_20191007_090756_at_iteration_97.png
pic_20191007_090756_at_iteration_98.png
pic_20191007_090756_at_iteration_99.png
pic_20191007_090756_at_iteration_9.png
pic2_at_iteration_0.png
pic2_at_iteration_10.png
pic2_at_iteration_11.png
pic2_at_iteration_12.png
pic2_at_iteration_13.png
pic2_at_iteration_14.png
pic2_at_iteration_15.png
pic2_at_iteration_16.png
pic2_at_iteration_17.png
pic2_at_iteration_18.png
pic2_at_iteration_1.png
pic2_at_iteration_2.png
pic2_at_iteration_3.png
pic2_at_iteration_4.png
pic2_at_iteration_5.png
pic2_at_iteration_6.png
```

```python
fnameout = outDir + '/' + result_prefix + '_at_iteration_%d.png' % (iterations-1)
imgout = load_img(fnameout, target_size=(300,400))
imgplot = plt.imshow(imgout)
print(fnameout)
```

/content/drive/My Drive/Colab Notebooks/out//pic_20191007_090756_at_iteration_99.png
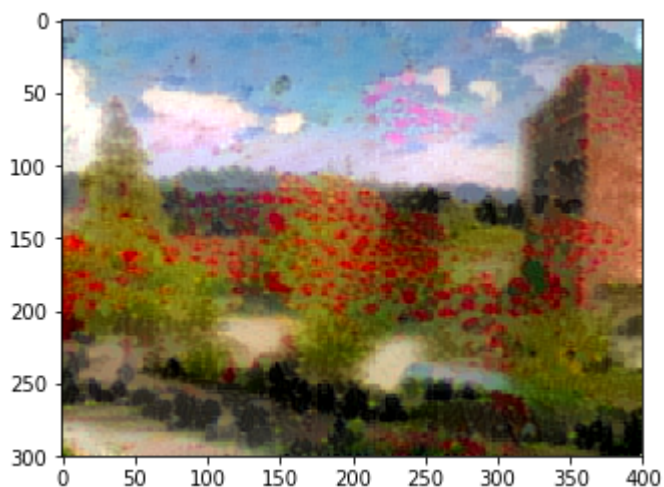
References

[1] Neural style transfer with Keras. https://keras.io/examples/neural_style_transfer/