2- Neural Style Transfer with 'Madhubani' Painting Style

```
import numpy as np
from PIL import Image
import requests
from io import BytesIO

from keras import backend
from keras.models import Model
from keras.applications.vgg16 import VGG16

from scipy.optimize import fmin_l_bfgs_b
```

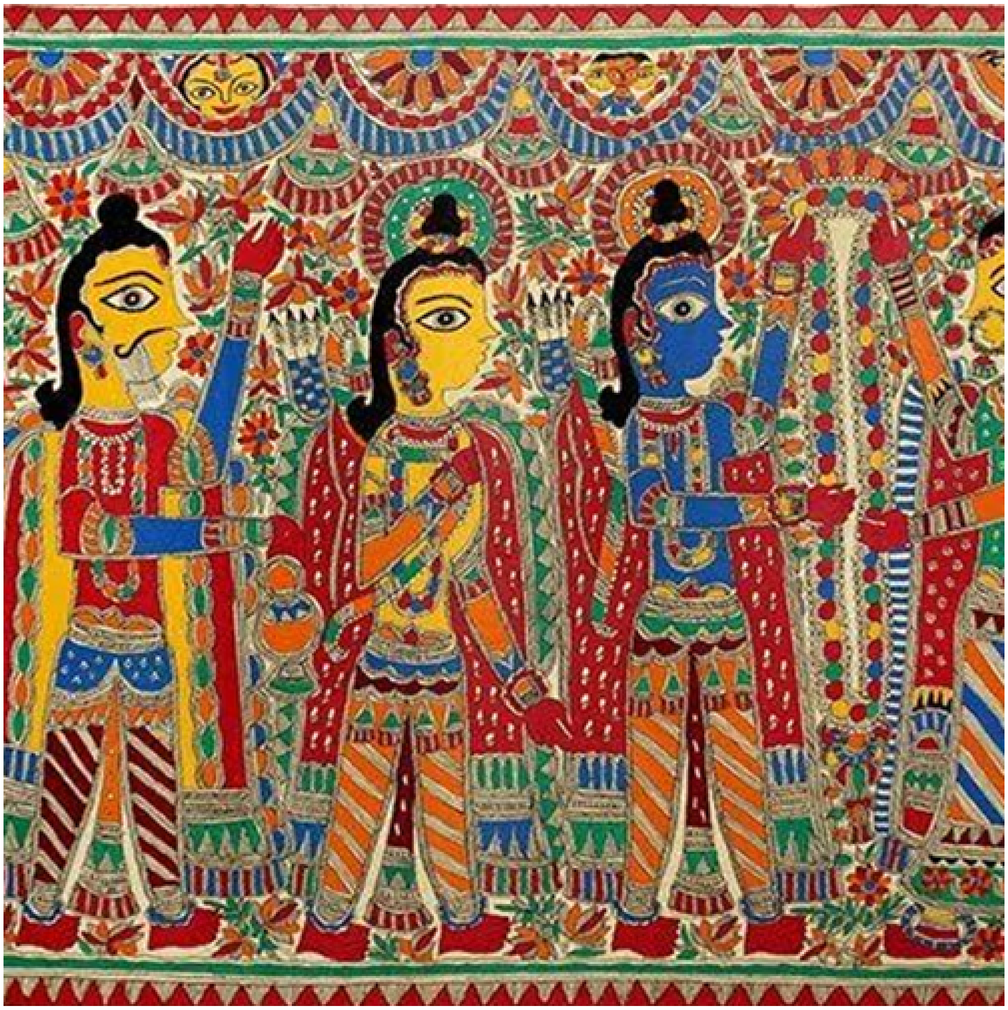
```
Using TensorFlow backend.
```

```
ITERATIONS = 10
CHANNELS = 3
IMAGE_SIZE = 500
IMAGE_WIDTH = IMAGE_SIZE
IMAGE_HEIGHT = IMAGE_SIZE
IMAGENET_MEAN_RGB_VALUES = [123.68, 116.779, 103.939]
CONTENT_WEIGHT = 0.02
STYLE_WEIGHT = 4.5
TOTAL_VARIATION_WEIGHT = 0.995
TOTAL_VARIATION_LOSS_FACTOR = 1.25
```

```
input_image_path = "input.png"
style_image_path = "style.png"
output_image_path = "output.png"
```

```
#Input visualization - Content
input_image = Image.open("/content/Csueastbay1.jpg")
input_image = input_image.resize((IMAGE_WIDTH, IMAGE_HEIGHT))
input_image.save(input_image_path)
input_image
```

```
# Style visualization - Style
style_image = Image.open("/content/36.jpg")
style_image = style_image.resize((IMAGE_WIDTH, IMAGE_HEIGHT))
style_image.save(style_image_path)
style_image
```



```
# Data normalization and reshaping from RGB to BGR
input_image_array = np.asarray(input_image, dtype="float32")
input_image_array = np.expand_dims(input_image_array, axis=0)
input_image_array[:, :, :, 0] -= IMAGENET_MEAN_RGB_VALUES[2]
input_image_array[:, :, :, 1] -= IMAGENET_MEAN_RGB_VALUES[1]
input_image_array[:, :, :, 2] -= IMAGENET_MEAN_RGB_VALUES[0]
input_image_array = input_image_array[:, :, :, ::-1]

style_image_array = np.asarray(style_image, dtype="float32")
style_image_array = np.expand_dims(style_image_array, axis=0)
style_image_array[:, :, :, 0] -= IMAGENET_MEAN_RGB_VALUES[2]
style_image_array[:, :, :, 1] -= IMAGENET_MEAN_RGB_VALUES[1]
style_image_array[:, :, :, 2] -= IMAGENET_MEAN_RGB_VALUES[0]
style_image_array = style_image_array[:, :, :, ::-1]


# Model
input_image = backend.variable(input_image_array)
style_image = backend.variable(style_image_array)
combination_image = backend.placeholder((1, IMAGE_HEIGHT, IMAGE_SIZE, 3))

input_tensor = backend.concatenate([input_image,style_image,combination_image], axis=
model = VGG16(input_tensor=input_tensor, include_top=False)
```

```
Downloading data from https://github.com/fchollet/deep-learning-models/releases/
58892288/58889256 [==============================] - 6s 0us/step
```

```
def content_loss(content, combination):
    return backend.sum(backend.square(combination - content))

layers = dict([(layer.name, layer.output) for layer in model.layers])

content_layer = 'block2_conv2'
layer_features = layers[content_layer]
content_image_features = layer_features[0, :, :, :]
combination_features = layer_features[2, :, :, :]

loss = backend.variable(0.)
loss =loss+ CONTENT_WEIGHT * content_loss(content_image_features,
                                      combination_features)


def gram_matrix(x):
    features = backend.batch_flatten(backend.permute_dimensions(x, (2, 0, 1)))
    gram = backend.dot(features, backend.transpose(features))
    return gram


def compute_style_loss(style, combination):
    style = gram_matrix(style)
    combination = gram_matrix(combination)
    size = IMAGE_HEIGHT * IMAGE_WIDTH
    return backend.sum(backend.square(style - combination)) / (4. * (CHANNELS ** 2) *

style_layers = ["block1_conv2", "block2_conv2", "block3_conv3", "block4_conv3", "bloc
for layer_name in style_layers:
    layer_features = layers[layer_name]
    style_features = layer_features[1, :, :, :]
    combination_features = layer_features[2, :, :, :]
    style_loss = compute_style_loss(style_features, combination_features)
    loss =loss+ (STYLE_WEIGHT / len(style_layers)) * style_loss


def total_variation_loss(x):
    a = backend.square(x[:, :IMAGE_HEIGHT-1, :IMAGE_WIDTH-1, :] - x[:, 1:, :IMAGE_WID
    b = backend.square(x[:, :IMAGE_HEIGHT-1, :IMAGE_WIDTH-1, :] - x[:, :IMAGE_HEIGHT-
    return backend.sum(backend.pow(a + b, TOTAL_VARIATION_LOSS_FACTOR))

loss =loss+ TOTAL_VARIATION_WEIGHT * total_variation_loss(combination_image)


outputs = [loss]
outputs += backend.gradients(loss, combination_image)

def evaluate_loss_and_gradients(x):
    x = x.reshape((1, IMAGE_HEIGHT, IMAGE_WIDTH, CHANNELS))
```

```
    outs = backend.function([combination_image], outputs)([x])
    loss = outs[0]
    gradients = outs[1].flatten().astype("float64")
    return loss, gradients

class Evaluator:

    def loss(self, x):
        loss, gradients = evaluate_loss_and_gradients(x)
        self._gradients = gradients
        return loss

    def gradients(self, x):
        return self._gradients

evaluator = Evaluator()


outputs = [loss]
outputs += backend.gradients(loss, combination_image)

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evaluator = Evaluator()


x = np.random.uniform(0, 255, (1, IMAGE_HEIGHT, IMAGE_WIDTH, 3)) - 128.

for i in range(ITERATIONS):
    x, loss, info = fmin_l_bfgs_b(evaluator.loss, x.flatten(), fprime=evaluator.gradi
    print("Iteration %d completed with loss %d" % (i, loss))

x = x.reshape((IMAGE_HEIGHT, IMAGE_WIDTH, CHANNELS))
x = x[:, :, ::-1]
x[:, :, 0] += IMAGENET_MEAN_RGB_VALUES[2]
x[:, :, 1] += IMAGENET_MEAN_RGB_VALUES[1]
x[:, :, 2] += IMAGENET_MEAN_RGB_VALUES[0]
x = np.clip(x, 0, 255).astype("uint8")
```

```
output_image = Image.fromarray(x)
output_image.save(output_image_path)
# Output
output_image
```

```
Iteration 0 completed with loss 149901443072
Iteration 1 completed with loss 93296099328
Iteration 2 completed with loss 74111426560
Iteration 3 completed with loss 66574176256
Iteration 4 completed with loss 62600998912
Iteration 5 completed with loss 60307472384
Iteration 6 completed with loss 59194380288
Iteration 7 completed with loss 58550304768
Iteration 8 completed with loss 58085662720
Iteration 9 completed with loss 57757417472
```