```
import os
import tensorflow as tf
os.environ['TFHUB_MODEL_LOAD_FORMAT'] = 'COMPRESSED'
```

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

```
     Drive already mounted at /content/drive; to attempt to forcibly remount, call
```

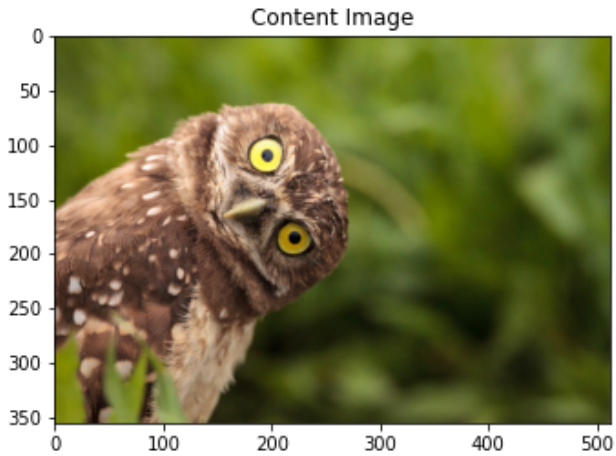
```
import IPython.display as display

import matplotlib.pyplot as plt
import matplotlib as mpl
mpl.rcParams['figure.figsize'] = (12, 12)
mpl.rcParams['axes.grid'] = False

import numpy as np
import PIL.Image
import time
import functools
```

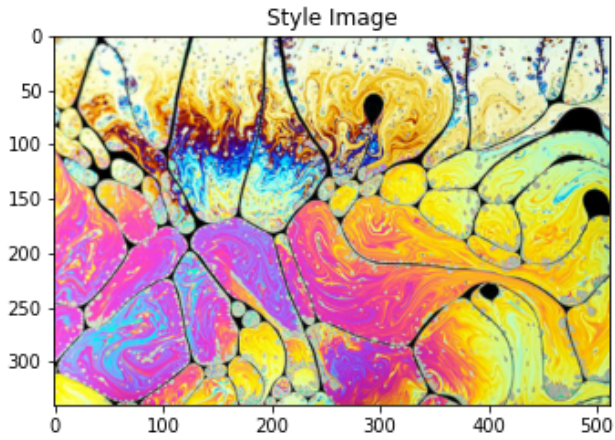
```
def tensor_to_image(tensor):
  tensor = tensor*255
  tensor = np.array(tensor, dtype=np.uint8)
  if np.ndim(tensor)>3:
    assert tensor.shape[0] == 1
    tensor = tensor[0]
  return PIL.Image.fromarray(tensor)
```

```
def load_img(path_to_img):
  max_dim = 512
  img = tf.io.read_file(path_to_img)
  img = tf.image.decode_image(img, channels=3)
  img = tf.image.convert_image_dtype(img, tf.float32)

  shape = tf.cast(tf.shape(img)[:-1], tf.float32)
  long_dim = max(shape)
  scale = max_dim / long_dim

  new_shape = tf.cast(shape * scale, tf.int32)

  img = tf.image.resize(img, new_shape)
  img = img[tf.newaxis, :]
  return img
```

```
def imshow(image, title=None):
  if len(image.shape) > 3:
    image = tf.squeeze(image, axis=0)

  plt.imshow(image)
  if title:
```

```
  if title:
    plt.title(title)


content_image = load_img("/owl.jpg")
style_image = load_img("/style.jpeg")

plt.subplot(1, 2, 1)
imshow(content_image, 'Content Image')

plt.subplot(1, 2, 2)
imshow(style_image, 'Style Image')
```






```
import tensorflow_hub as hub
hub_model = hub.load('https://tfhub.dev/google/magenta/arbitrary-image-stylization-
stylized_image = hub_model(tf.constant(content_image), tf.constant(style_image))[0]
tensor_to_image(stylized_image)
```

```
x = tf.keras.applications.vgg19.preprocess_input(content_image*255)
x = tf.image.resize(x, (224, 224))
```

```
vgg = tf.keras.applications.VGG19(include_top=True, weights='imagenet')
prediction_probabilities = vgg(x)
prediction_probabilities.shape
```

```
TensorShape([1, 1000])
```

```
predicted_top_5 = tf.keras.applications.vgg19.decode_predictions(prediction_probabi
[(class_name, prob) for (number, class_name, prob) in predicted_top_5]
```

```
[('great_grey_owl', 0.73142934),
 ('ringlet', 0.051973876),
 ('bittern', 0.049039505),
 ('vulture', 0.03952588),
 ('kite', 0.029020881)]
```

```
vgg = tf.keras.applications.VGG19(include_top=False, weights='imagenet')

print()
for layer in vgg.layers:
  print(layer.name)
```

```
input_17
block1_conv1
block1_conv2
block1_pool
block2_conv1
block2_conv2
block2_pool
block3_conv1
block3_conv2
block3_conv3
block3_conv4
block3_pool
block4_conv1
block4_conv2
block4_conv3
block4_conv4
block4_pool
block5_conv1
block5_conv2
block5_conv3
block5_conv4
block5_pool
```

```
content_layers = ['block5_conv2']

style_layers = ['block1_conv1',
                'block2_conv1',
                'block3_conv1',
                'block4_conv1',
                'block5_conv1']

num_content_layers = len(content_layers)
num_style_layers = len(style_layers)
```

```
def vgg_layers(layer_names):

  vgg = tf.keras.applications.VGG19(include_top=False, weights='imagenet')
  vgg.trainable = False

  outputs = [vgg.get_layer(name).output for name in layer_names]

  model = tf.keras.Model([vgg.input], outputs)
  return model


style_extractor = vgg_layers(style_layers)
style_outputs = style_extractor(style_image*255)


for name, output in zip(style_layers, style_outputs):
  print(name)
  print("  shape: ", output.numpy().shape)
  print("  min: ", output.numpy().min())
  print("  max: ", output.numpy().max())
  print("  mean: ", output.numpy().mean())
  print()
```

```
    block1_conv1
      shape:  (1, 341, 512, 64)
      min:  0.0
      max:  836.31885
      mean:  49.30245

    block2_conv1
      shape:  (1, 170, 256, 128)
      min:  0.0
      max:  5778.871
      mean:  260.07843

    block3_conv1
      shape:  (1, 85, 128, 256)
      min:  0.0
      max:  12648.359
      mean:  290.02325

    block4_conv1
      shape:  (1, 42, 64, 512)
      min:  0.0
      max:  25104.59
      mean:  917.1499

    block5_conv1
      shape:  (1, 21, 32, 512)
      min:  0.0
      max:  3712.8596
      mean:  59.95148
```

```
def gram_matrix(input_tensor):
  result = tf.linalg.einsum('bijc,bijd->bcd', input_tensor, input_tensor)
  input_shape = tf.shape(input_tensor)
  num_locations = tf.cast(input_shape[1]*input_shape[2], tf.float32)
```

```
    return result/(num_locations)


class StyleContentModel(tf.keras.models.Model):
  def __init__(self, style_layers, content_layers):
    super(StyleContentModel, self).__init__()
    self.vgg = vgg_layers(style_layers + content_layers)
    self.style_layers = style_layers
    self.content_layers = content_layers
    self.num_style_layers = len(style_layers)
    self.vgg.trainable = False

  def call(self, inputs):
    "Expects float input in [0,1]"
    inputs = inputs*255.0
    preprocessed_input = tf.keras.applications.vgg19.preprocess_input(inputs)
    outputs = self.vgg(preprocessed_input)
    style_outputs, content_outputs = (outputs[:self.num_style_layers],
                                      outputs[self.num_style_layers:])

    style_outputs = [gram_matrix(style_output)
                     for style_output in style_outputs]

    content_dict = {content_name: value
                    for content_name, value
                    in zip(self.content_layers, content_outputs)}

    style_dict = {style_name: value
                  for style_name, value
                  in zip(self.style_layers, style_outputs)}

    return {'content': content_dict, 'style': style_dict}


extractor = StyleContentModel(style_layers, content_layers)

results = extractor(tf.constant(content_image))

print('Styles:')
for name, output in sorted(results['style'].items()):
  print("  ", name)
  print("    shape: ", output.numpy().shape)
  print("    min: ", output.numpy().min())
  print("    max: ", output.numpy().max())
  print("    mean: ", output.numpy().mean())
  print()

print("Contents:")
for name, output in sorted(results['content'].items()):
  print("  ", name)
  print("    shape: ", output.numpy().shape)
  print("    min: ", output.numpy().min())
  print("    max: ", output.numpy().max())
  print("    mean: ", output.numpy().mean())
```

```
    Styles:
       block1_conv1
        shape:  (1, 64, 64)
        min:  0.002655763
        max:  16853.451
        mean:  337.22418

       block2_conv1
        shape:  (1, 128, 128)
        min:  0.0
        max:  48416.816
        mean:  9061.926

       block3_conv1
        shape:  (1, 256, 256)
        min:  0.0
        max:  317588.75
        mean:  8140.998

       block4_conv1
        shape:  (1, 512, 512)
        min:  0.0
        max:  3212877.0
        mean:  145063.1

       block5_conv1
        shape:  (1, 512, 512)
        min:  0.0
        max:  129496.65
        mean:  1231.7739

    Contents:
       block5_conv2
        shape:  (1, 22, 32, 512)
        min:  0.0
        max:  1756.408
        mean:  12.337271
```

```
style_targets = extractor(style_image)['style']
content_targets = extractor(content_image)['content']
```

```
image = tf.Variable(content_image)
```

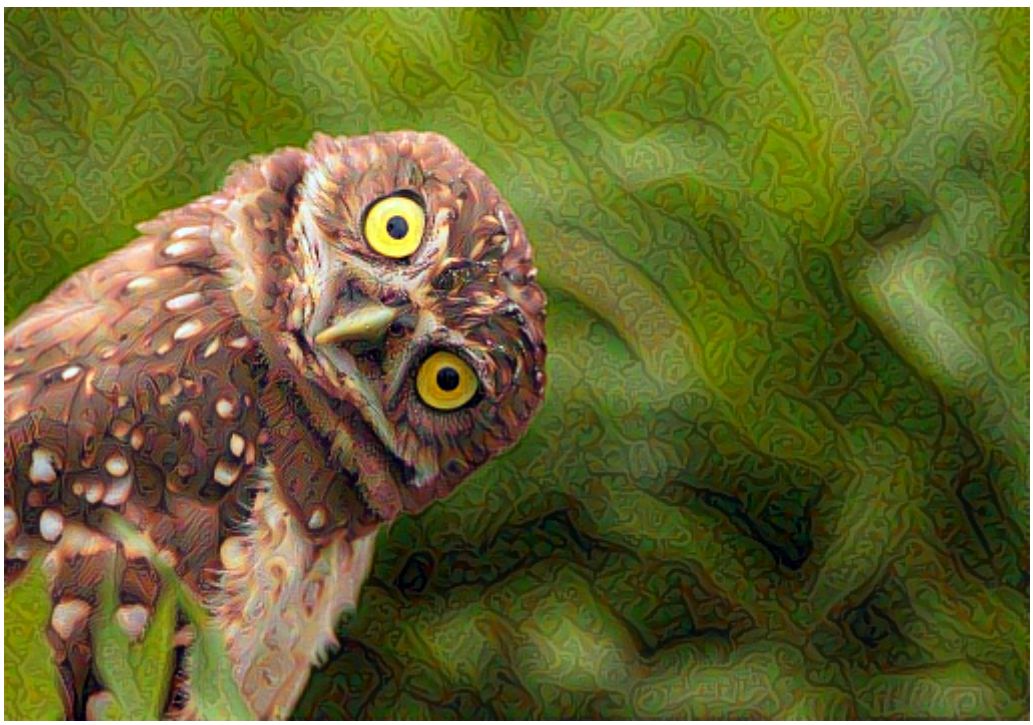
```
def clip_0_1(image):
  return tf.clip_by_value(image, clip_value_min=0.0, clip_value_max=1.0)
```

```
opt = tf.optimizers.Adam(learning_rate=0.02, beta_1=0.99, epsilon=1e-1)
```

```
style_weight=1e-2
content_weight=1e4
```

```
def style_content_loss(outputs):
    style_outputs = outputs['style']
    content_outputs = outputs['content']
```

```
    style_loss = tf.add_n([tf.reduce_mean((style_outputs[name]-style_targets[name])
                           for name in style_outputs.keys()])
    style_loss *= style_weight / num_style_layers

    content_loss = tf.add_n([tf.reduce_mean((content_outputs[name]-content_targets[
                             for name in content_outputs.keys()])
    content_loss *= content_weight / num_content_layers
    loss = style_loss + content_loss
    return loss


@tf.function()
def train_step(image):
  with tf.GradientTape() as tape:
    outputs = extractor(image)
    loss = style_content_loss(outputs)

  grad = tape.gradient(loss, image)
  opt.apply_gradients([(grad, image)])
  image.assign(clip_0_1(image))


train_step(image)
train_step(image)
train_step(image)
tensor_to_image(image)
```

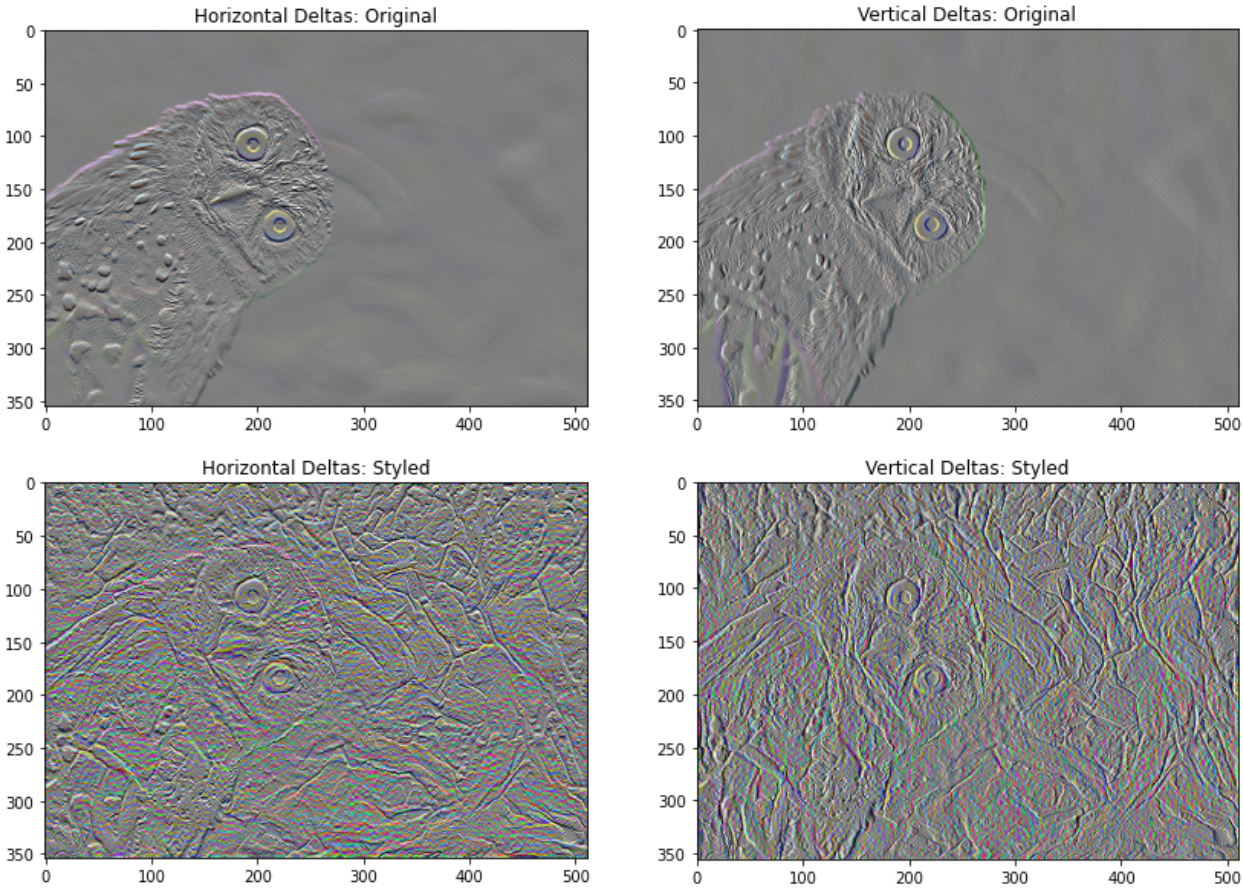


```
import time
start = time.time()

epochs = 10
steps_per_epoch = 100

step = 0
for n in range(epochs):
  for m in range(steps_per_epoch):
```

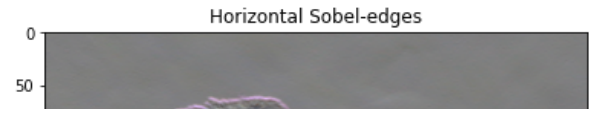
```
    for m in range(steps_per_epoch):
      step += 1
      train_step(image)
      print(".", end='', flush=True)
    display.clear_output(wait=True)
    display.display(tensor_to_image(image))
    print("Train step: {}".format(step))

end = time.time()
print("Total time: {:.1f}".format(end-start))
```

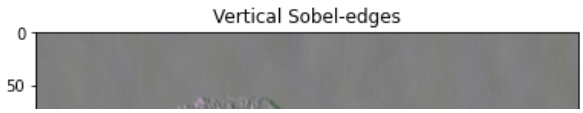
```
Train step: 1000
Total time: 69.7
```

```
def high_pass_x_y(image):
  x_var = image[:, :, 1:, :] - image[:, :, :-1, :]
  y_var = image[:, 1:, :, :] - image[:, :-1, :, :]

  return x_var, y_var


x_deltas, y_deltas = high_pass_x_y(content_image)

plt.figure(figsize=(14, 10))
plt.subplot(2, 2, 1)
imshow(clip_0_1(2*y_deltas+0.5), "Horizontal Deltas: Original")

plt.subplot(2, 2, 2)
imshow(clip_0_1(2*x_deltas+0.5), "Vertical Deltas: Original")

x_deltas, y_deltas = high_pass_x_y(image)

plt.subplot(2, 2, 3)
imshow(clip_0_1(2*y_deltas+0.5), "Horizontal Deltas: Styled")

plt.subplot(2, 2, 4)
imshow(clip_0_1(2*x_deltas+0.5), "Vertical Deltas: Styled")
```




```
plt.figure(figsize=(14, 10))

sobel = tf.image.sobel_edges(content_image)
plt.subplot(1, 2, 1)
imshow(clip_0_1(sobel[..., 0]/4+0.5), "Horizontal Sobel-edges")
plt.subplot(1, 2, 2)
imshow(clip_0_1(sobel[..., 1]/4+0.5), "Vertical Sobel-edges")
```






```
def total_variation_loss(image):
  x_deltas, y_deltas = high_pass_x_y(image)
  return tf.reduce_sum(tf.abs(x_deltas)) + tf.reduce_sum(tf.abs(y_deltas))
```

```
total_variation_loss(image).numpy()
```

```
144818.97
```

```
tf.image.total_variation(image).numpy()
```

```
array([144818.97], dtype=float32)
```

```
total_variation_weight=30
```

```
@tf.function()
def train_step(image):
  with tf.GradientTape() as tape:
    outputs = extractor(image)
    loss = style_content_loss(outputs)
    loss += total_variation_weight*tf.image.total_variation(image)

  grad = tape.gradient(loss, image)
  opt.apply_gradients([(grad, image)])
  image.assign(clip_0_1(image))
```

```
image = tf.Variable(content_image)
```

```
import time
start = time.time()

epochs = 10
steps_per_epoch = 100

step = 0
for n in range(epochs):
  for m in range(steps_per_epoch):
    step += 1
    train_step(image)
    print(".", end='', flush=True)
  display.clear_output(wait=True)
  display.display(tensor_to_image(image))
  print("Train step: {}".format(step))

end = time.time()
print("Total time: {:.1f}".format(end-start))
```

```
Train step: 1000
```

```
file_name = 'stylized_tranfer_image.png'
tensor_to_image(image).save(file_name)

try:
  from google.colab import files
except ImportError:
   pass
else:
  files.download(file_name)
```