Programming Project #1: Hybrid Images

CS445: Computational Photography

Part I: Hybrid Images

```
import cv2

import numpy as np
from matplotlib.colors import LogNorm
from scipy import signal

# modify to where you store your project data including utils.py
datadir = "/home/trs07170/UIUC/cs445/Project 1/"

# utilfn = datadir + "utils.py"
# !cp "$utilfn" .
import utils

# switch from notebook to inline if using colab or otherwise cannot
use interactive display)
%matplotlib notebook
# %matplotlib inline
import matplotlib.pyplot as plt

%load_ext autoreload
%autoreload 2
```

Function definition

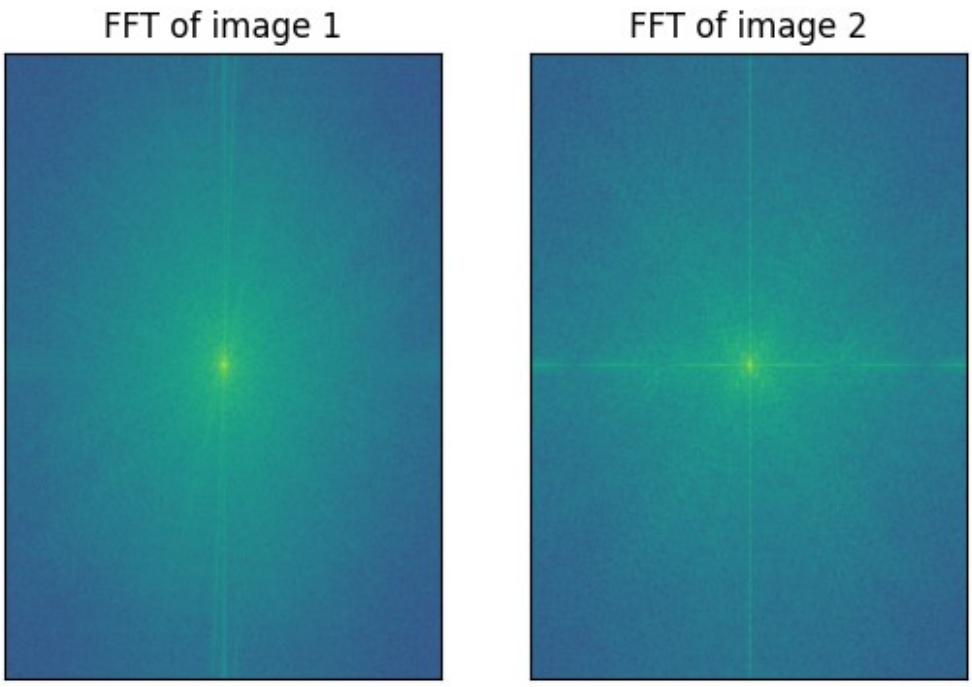
```
def hybridImage(im1, im2, sigma_low, sigma_high):
    '''
    Inputs:
        im1:    RGB (height x width x 3) or a grayscale (height x
width) image
                as a numpy array. low-pass image
        im2:    RGB (height x width x 3) or a grayscale (height x
width) image
                as a numpy array. high-pass image
        sigma_low: standard deviation for the low-pass filter
        sigma_high: standard deviation for the high-pass filter

    Output:
        Return the combination of both images, one filtered with a
low-pass filter
        and the other with a high-pass filter.
    '''
    def gaussian_kernel(sigma):
```

```
        """ Generates a 2D Gaussian kernel. """
        # ksize = int(np.ceil(sigma) * 6 + 1)
        ksize = 121
        flt = cv2.getGaussianKernel(ksize, sigma) # 1D kernel
        flt = flt*np.transpose(flt) # 2D kernel by outer product
        return flt

    lp_flt, hp_flt = gaussian_kernel(sigma_low),
gaussian_kernel(sigma_high)
    lp_img = cv2.filter2D(im1, -1, lp_flt)
    hp_img = im2 - cv2.filter2D(im2, -1, hp_flt)

    return lp_img, hp_img
    # return lp_img
    # return hp_img
```

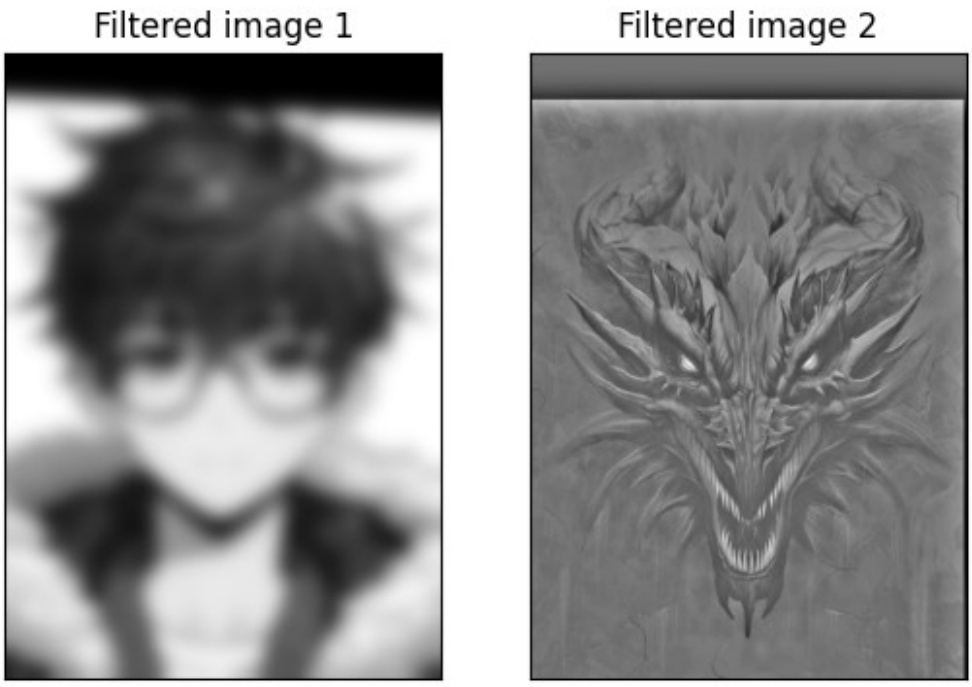
Pair 1 (Best)

```
im1_file = datadir + 'assets/trs.jpeg'
im2_file = datadir + 'assets/dragon.jpg'

im1 = np.float32(cv2.imread(im1_file, cv2.IMREAD_GRAYSCALE) / 255.0)
im2 = np.float32(cv2.imread(im2_file, cv2.IMREAD_GRAYSCALE) / 255.0)

pts_im1 = utils.prompt_eye_selection(im1)
# pts_im1 = np.array([[412, 433], [624, 424]])
# plt.plot(pts_im1[:,0], pts_im1[:,1], 'r-+')

pts_im2 = utils.prompt_eye_selection(im2)
# pts_im2 = np.array([[247, 542], [672, 543]])
# plt.plot(pts_im2[:,0], pts_im2[:,1], 'r-+')

im1, im2 = utils.align_images(im1_file,
im2_file,pts_im1,pts_im2,save_images=False)

# convert to grayscale
im1 = cv2.cvtColor(im1, cv2.COLOR_BGR2GRAY) / 255.0
im2 = cv2.cvtColor(im2, cv2.COLOR_BGR2GRAY) / 255.0

#Images sanity check
fig, axes = plt.subplots(1, 2)
axes[0].imshow(im1,cmap='gray')
axes[0].set_title('Image 1'), axes[0].set_xticks([]),
axes[0].set_yticks([])
axes[1].imshow(im2,cmap='gray')
axes[1].set_title('Image 2'), axes[1].set_xticks([]),
axes[1].set_yticks([]);
```

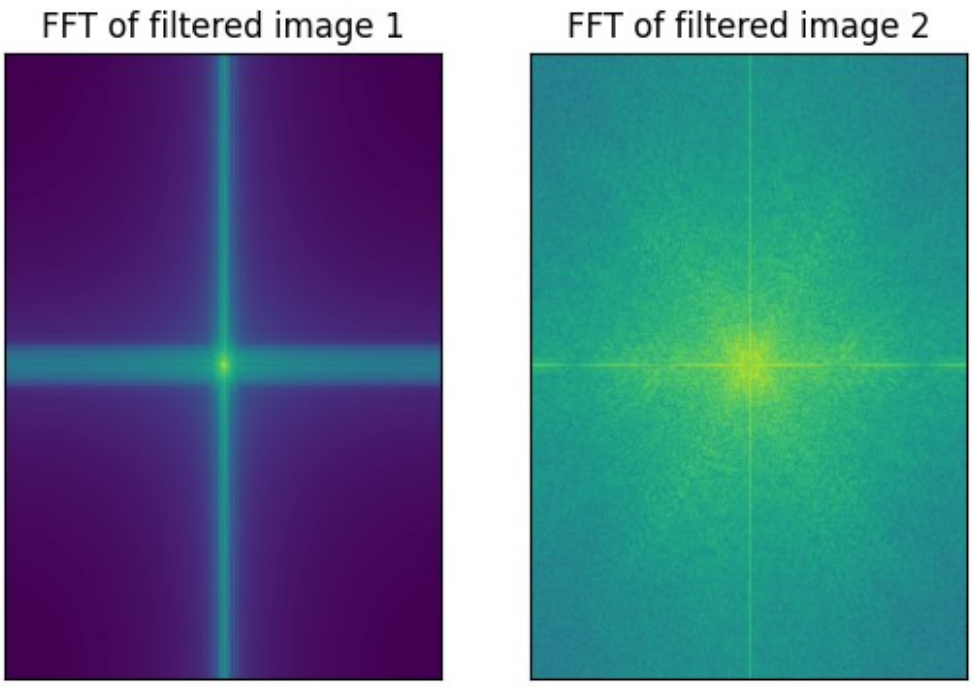

```
# log magnitude of the Fourier transform of original images
fig, axes = plt.subplots(1, 2)
axes[0].imshow(np.log(np.abs(np.fft.fftshift(np.fft.fft2(im1)))))
axes[0].set_title('FFT of image 1'), axes[0].set_xticks([]),
axes[0].set_yticks([])
axes[1].imshow(np.log(np.abs(np.fft.fftshift(np.fft.fft2(im2)))))
axes[1].set_title('FFT of image 2'), axes[1].set_xticks([]),
axes[1].set_yticks([]);
```




```
sigma_low = 10 # choose parameters that work for your images
sigma_high = 15

lp_img, hp_img = hybridImage(im1, im2, sigma_low, sigma_high)

# filtered images
fig, axes = plt.subplots(1, 2)
axes[0].imshow(lp_img, cmap='gray')
axes[0].set_title('Filtered image 1'), axes[0].set_xticks([]),
axes[0].set_yticks([])
axes[1].imshow(hp_img, cmap='gray')
axes[1].set_title('Filtered image 2'), axes[1].set_xticks([]),
axes[1].set_yticks([]);
```

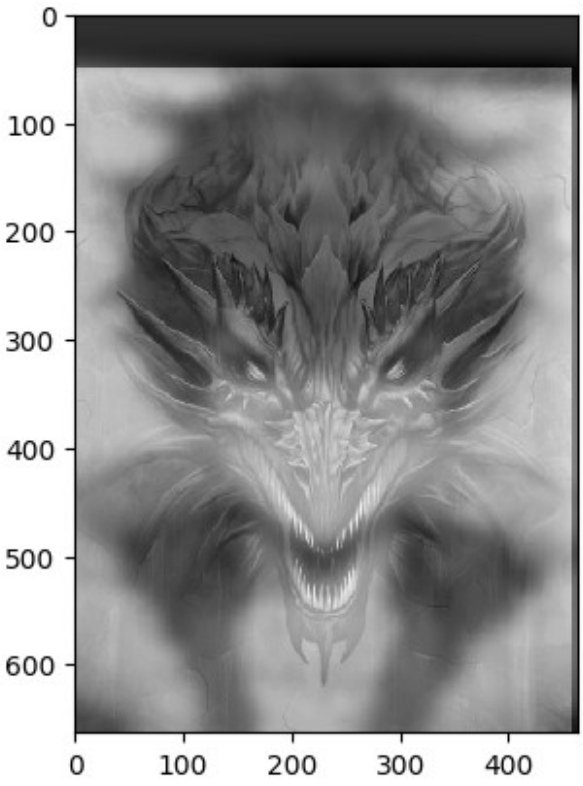



```
# log magnitude of the Fourier transform of filtered images
fig, axes = plt.subplots(1, 2)
axes[0].imshow(np.log(np.abs(np.fft.fftshift(np.fft.fft2(lp_img)))))
axes[0].set_title('FFT of filtered image 1'), axes[0].set_xticks([]),
axes[0].set_yticks([])
axes[1].imshow(np.log(np.abs(np.fft.fftshift(np.fft.fft2(hp_img)))))
axes[1].set_title('FFT of filtered image 2'), axes[1].set_xticks([]),
axes[1].set_yticks([]);
```



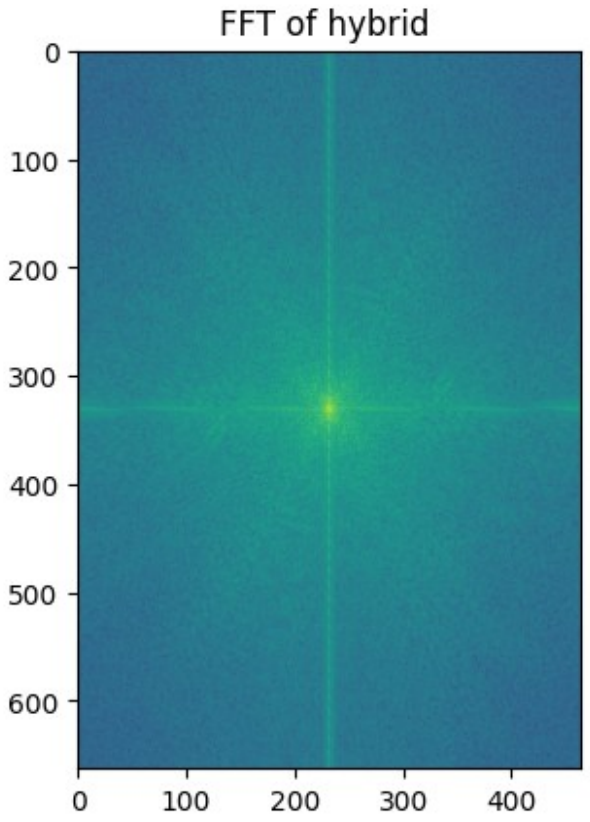

```
im_hybrid = lp_img + hp_img
plt.imshow(im_hybrid, interpolation='none', cmap='gray')
```

```
<matplotlib.image.AxesImage at 0x7ffa9961cdc0>
```



```
im_hybrid = lp_img + hp_img
plt.imshow(np.log(np.abs(np.fft.fftshift(np.fft.fft2(im_hybrid)))))
plt.title("FFT of hybrid ")
```

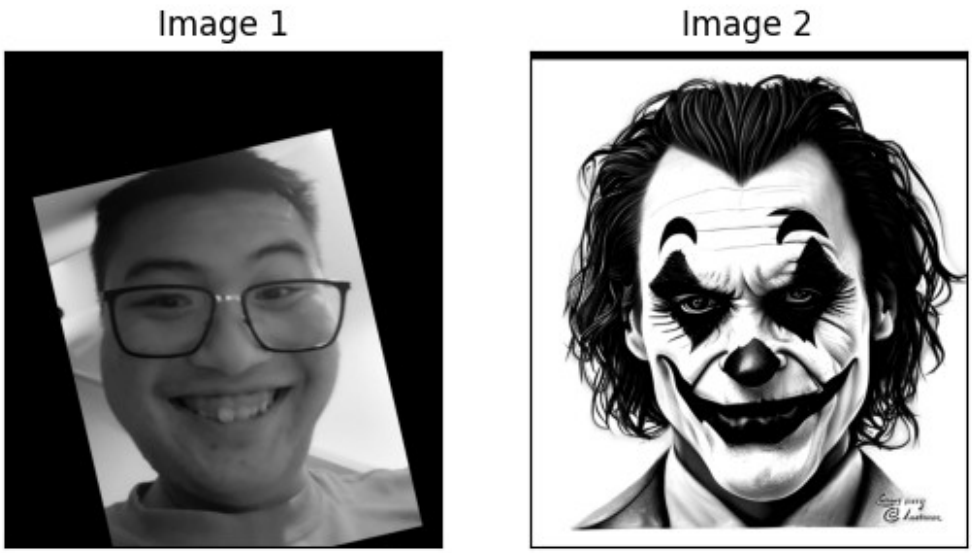
```
Text(0.5, 1.0, 'FFT of hybrid ')
```



Pair 2

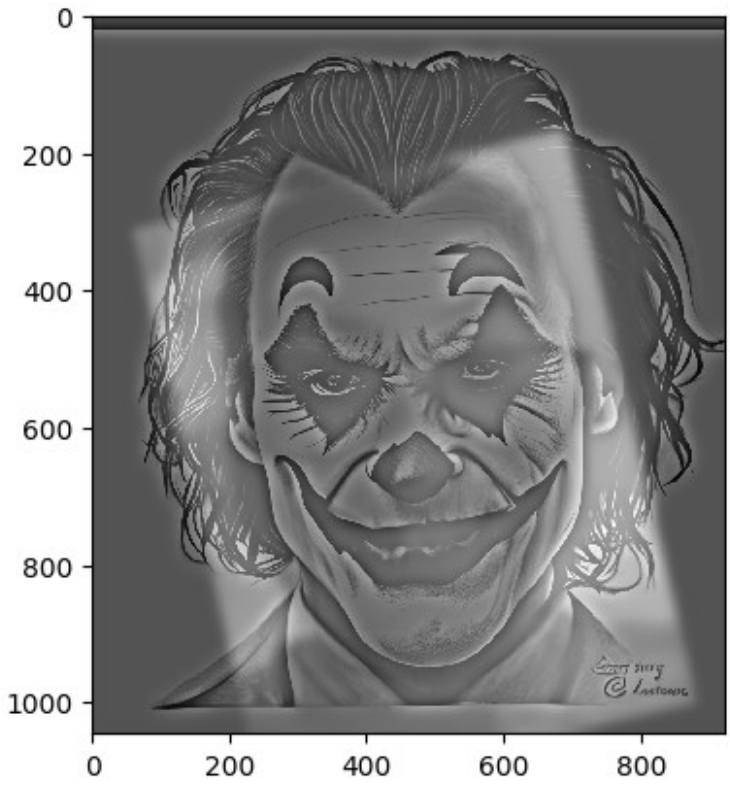
```
im1_file = datadir + 'assets/ljc.jpg'
im2_file = datadir + 'assets/joker.png'

im1 = np.float32(cv2.imread(im1_file, cv2.IMREAD_GRAYSCALE) / 255.0)
im2 = np.float32(cv2.imread(im2_file, cv2.IMREAD_GRAYSCALE) / 255.0)

pts_im1 = utils.prompt_eye_selection(im1)

pts_im2 = utils.prompt_eye_selection(im2)

im1, im2 = utils.align_images(im1_file,
im2_file,pts_im1,pts_im2,save_images=False)

# convert to grayscale
im1 = cv2.cvtColor(im1, cv2.COLOR_BGR2GRAY) / 255.0
im2 = cv2.cvtColor(im2, cv2.COLOR_BGR2GRAY) / 255.0
```

```
#Images sanity check
fig, axes = plt.subplots(1, 2)
axes[0].imshow(im1,cmap='gray')
axes[0].set_title('Image 1'), axes[0].set_xticks([]),
axes[0].set_yticks([])
axes[1].imshow(im2,cmap='gray')
axes[1].set_title('Image 2'), axes[1].set_xticks([]),
axes[1].set_yticks([]);
```




```
sigma_low = 8 # choose parameters that work for your images
sigma_high = 11

lp_img, hp_img = hybridImage(im1, im2, sigma_low, sigma_high)
im_hybrid = lp_img + hp_img
plt.imshow(im_hybrid, interpolation='none', cmap='gray')
```

```
<matplotlib.image.AxesImage at 0x7f2c2fa5e5f0>
```

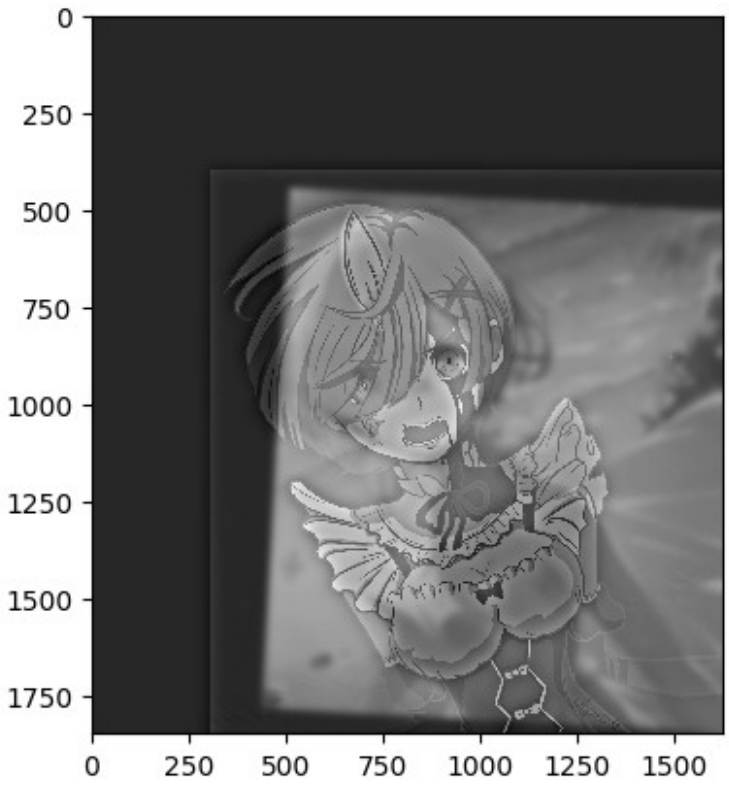


Pair 3

```
im1_file = datadir + 'assets/rem1.png'
im2_file = datadir + 'assets/rem2.jpg'

im1 = np.float32(cv2.imread(im1_file, cv2.IMREAD_GRAYSCALE) / 255.0)
im2 = np.float32(cv2.imread(im2_file, cv2.IMREAD_GRAYSCALE) / 255.0)

pts_im1 = utils.prompt_eye_selection(im1)

pts_im2 = utils.prompt_eye_selection(im2)

im1, im2 = utils.align_images(im1_file,
im2_file,pts_im1,pts_im2,save_images=False)

# convert to grayscale
im1 = cv2.cvtColor(im1, cv2.COLOR_BGR2GRAY) / 255.0
im2 = cv2.cvtColor(im2, cv2.COLOR_BGR2GRAY) / 255.0

#Images sanity check
fig, axes = plt.subplots(1, 2)
axes[0].imshow(im1,cmap='gray')
axes[0].set_title('Image 1'), axes[0].set_xticks([]),
axes[0].set_yticks([])
axes[1].imshow(im2,cmap='gray')
axes[1].set_title('Image 2'), axes[1].set_xticks([]),
axes[1].set_yticks([]);
```


```
sigma_low = 10 # choose parameters that work for your images
sigma_high = 20

lp_img, hp_img = hybridImage(im1, im2, sigma_low, sigma_high)
im_hybrid = lp_img + hp_img
plt.imshow(im_hybrid, interpolation='none', cmap='gray')
```

```
<matplotlib.image.AxesImage at 0x7f2c2f8ccc70>
```




```
# Optional: Select top left corner and bottom right corner to crop
image
# the function returns dictionary of
# {
#   'cropped_image': np.ndarray of shape H x W
#   'crop_bound': np.ndarray of shape 2x2
# }
cropped_object = utils.interactive_crop(im_hybrid)
```

Part II: Image Enhancement

Two out of three types of image enhancement are required. Choose a good image to showcase each type and implement a method. This code doesn't rely on the hybrid image part.

Contrast enhancement

```
image = cv2.imread(datadir + 'assets/sunset.jpg')
result = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)
result[:,:,2] = cv2.equalizeHist(result[:,:,2]) # only equalize the
Value channel

# OpenCV read image in BGR, whereas Matplotlib writes image in RGB
result = cv2.cvtColor(result, cv2.COLOR_HSV2RGB)
image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
```

```
fig, axes = plt.subplots(1, 2)
axes[0].imshow(image)
axes[0].set_title('Original'), axes[0].set_xticks([]),
axes[0].set_yticks([])
axes[1].imshow(result)
axes[1].set_title('Enhanced'), axes[1].set_xticks([]),
axes[1].set_yticks([]);
```

Color enhancement

```
image = cv2.imread(datadir + 'assets/rem1.png')
result = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)
result[:,:,1] = result[:,:,1] + 25
result[:,:,1][result[:,:,1] > 255] = 255
result = cv2.cvtColor(result, cv2.COLOR_HSV2RGB)
image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)

fig, axes = plt.subplots(1, 2)
axes[0].imshow(image)
axes[0].set_title('Original'), axes[0].set_xticks([]),
axes[0].set_yticks([])
axes[1].imshow(result)
axes[1].set_title('Enhanced'), axes[1].set_xticks([]),
axes[1].set_yticks([]);
```

Original

Enhanced

Color shift