# Programming Project #1: Hybrid Images

## CS445: Computational Photography

### Part I: Hybrid Images

In [1]:
```
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 = "C:/Users/jackt/Desktop/CS445/cs445hybrid/data/"

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

In [2]:
```
# switch from notebook to inline if using colab or otherwise cannot use interactive display)
%matplotlib notebook
import matplotlib.pyplot as plt
```

In [3]:
```
im1_file = datadir + 'mav.jpg'
im2_file = datadir + 'wolf.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)
```

In [4]:
```
pts_im1 = utils.prompt_eye_selection(im1)
# pts_im1 = np.array([[607, 290], [748, 370]]) # uncomment if entering [x, y] pts manually
# plt.plot(pts_im1[:,0], pts_im1[:,1], 'r-+')
```

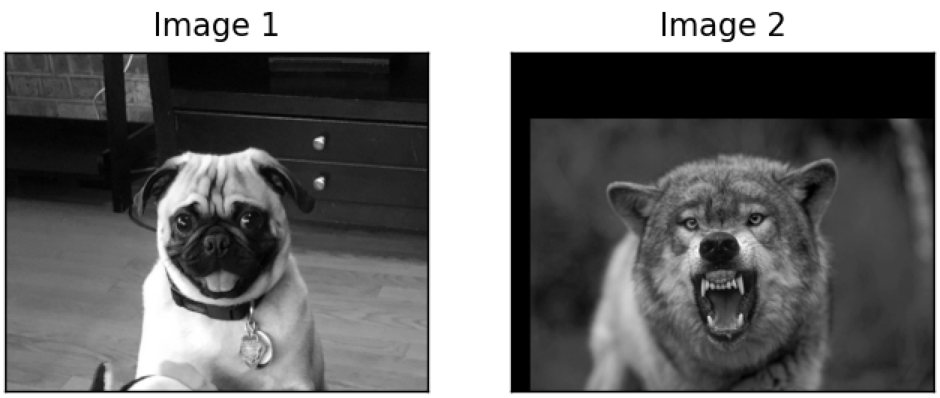
In [5]:
```
pts_im2 = utils.prompt_eye_selection(im2)
# pts_im2 = np.array([[299,343], [439,331]]) # uncomment if entering [x, y] pt
s manually
# plt.plot(pts_im2[:,0], pts_im2[:,1], 'r-+')
```

In [6]:
```
im1, im2 = utils.align_images(im1_file, im2_file,pts_im1,pts_im2,save_images=F
alse)
```

In [7]:
```
# convert to grayscale
im1 = cv2.cvtColor(im1, cv2.COLOR_BGR2GRAY) / 255.0
im2 = cv2.cvtColor(im2, cv2.COLOR_BGR2GRAY) / 255.0
```

In [8]:

```
#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([]);
```



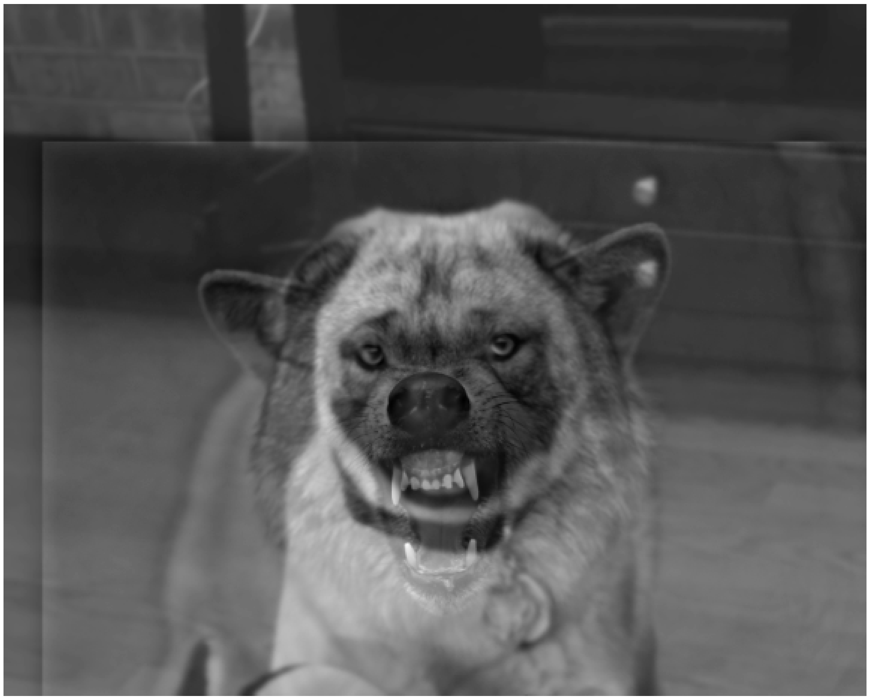
In [9]:

```
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.
        im2:    RGB (height x width x 3) or a grayscale (height x width) image
                as a numpy array.
        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 fi
lter
        and the other with a high-pass filter.
    '''
    is_rgb = (im1.shape == 3)  #TODO B&W handle this case

    # Create Gaussian kernel for low frequency filtering
    kernel_half_size = 3*sigma_low
    kernel = utils.gaussian_kernel(sigma_low, kernel_half_size)

    # Apply low filter to first image
    fim1 = cv2.filter2D(im1, -1, kernel)

    # Create kernel for high frequency filtering
    kernel_half_size = 3*sigma_high
    kernel = -1*utils.gaussian_kernel(sigma_high, kernel_half_size)
    kernel[kernel_half_size,kernel_half_size] += 1

    # Apply high filter to second image
    fim2 = cv2.filter2D(im2,-1,kernel)

    # Combine the images into one
    hybrid = fim1+fim2
    hybrid /= 2

    return hybrid #, fim1, fim2
```

In [10]:

```
sigma_low = 2 # choose parameters that work for your images
sigma_high = 10

im_hybrid = hybridImage(im1, im2, sigma_low, sigma_high)
```

In [11]:
```
# 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

In [12]:
```
%matplotlib inline

path = "C:/Users/jackt/Desktop/CS445/cs445hybrid/data/plate.jpg"
im = cv2.imread(path, cv2.IMREAD_COLOR)
im = im[:,:,::-1]
```

In [13]:

```
def enhance_contrast(im, sigma):
    '''
    Contrast enhancement using Laplacian filtering
    '''
    # Create Laplacian kernel for filtering
    khs = 3*sigma
    kernel = -1 * utils.gaussian_kernel(sigma, khs)
    kernel[khs,khs] += 2

    # Apply filter to image
    fim = cv2.filter2D(im, -1, kernel)
    return fim
```

In [14]:

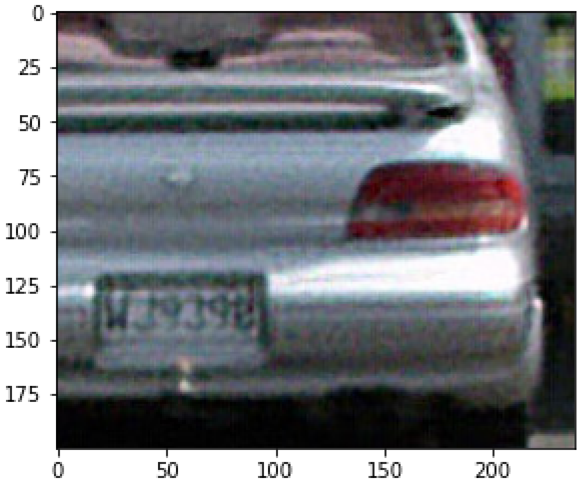
```
fim = enhance_contrast(im, 5)
```

In [15]:

```
plt.imshow(im)
```

Out[15]:

```
<matplotlib.image.AxesImage at 0x1d7ecd3f080>
```

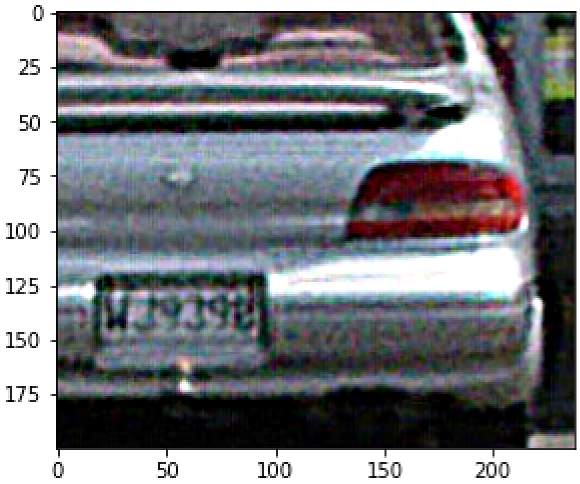


In [16]:

```
plt.imshow(fim)
```

Out[16]:

```
<matplotlib.image.AxesImage at 0x1d7ecdae0f0>
```



### Color enhancement

In [17]:

```python
def enhance_color(im, delta_s, delta_v):
    '''
    Color enhancement in HSV image im

    Increase S and V channels while staying in 0-255 range
    '''
    if delta_s < 1:
        delta_s = 1
    if delta_v < 1:
        delta_v = 1
    cim = im.copy()
    cim[:,:,1] = 255 - (255 - cim[:,:,1]) // delta_s
    cim[:,:,2] = 255 - (255 - cim[:,:,2]) // delta_v
    return cim
```

In [18]:

```python
path = "C:/Users/jackt/Desktop/CS445/cs445hybrid/data/mav2.jpg"
im = cv2.imread(path, cv2.IMREAD_COLOR)
hsv = cv2.cvtColor(im,cv2.COLOR_BGR2HSV)
```

In [19]:

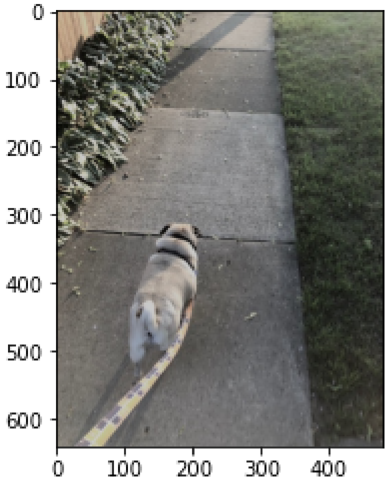
```python
cim = enhance_color(hsv, 1.1, 1.2)
```

In [20]:

```python
plt.imshow(cv2.cvtColor(im, cv2.COLOR_BGR2RGB))
```

Out[20]:

```
<matplotlib.image.AxesImage at 0x1d7ece1a2e8>
```

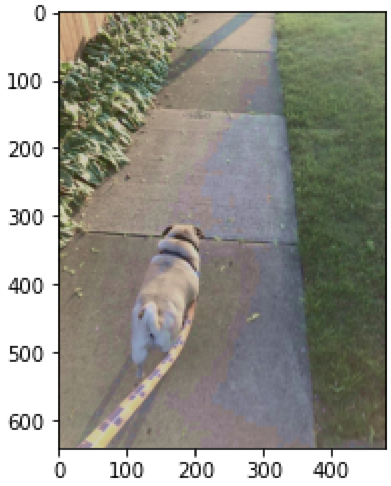


In [21]:

```
plt.imshow(cv2.cvtColor(cim, cv2.COLOR_HSV2RGB))
```

Out[21]:

```
<matplotlib.image.AxesImage at 0x1d7ed1c8710>
```



### Color shift

In [22]:

```
def shift_color(im, tgtH, delta):
    '''
    Color shift in HSV towards target tgtH

    Decrease radial distance of each pixel from tgtH
      by at most delta degrees
    '''
    if delta < 0:
        delta = 0
    sim = im.copy()
    x = ((sim[:,:,0] - tgtH + 180) % 360) - 180
    x = x * delta // -180
    sim[:,:,0] = (sim[:,:,0] + x) % 360
    return sim
```

In [23]:

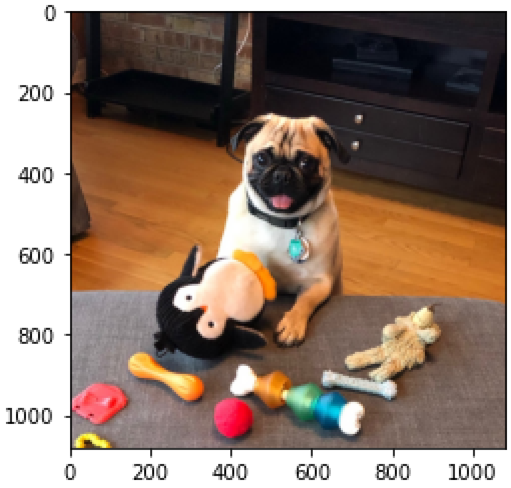
```
path = "C:/Users/jackt/Desktop/CS445/cs445hybrid/data/mav.jpg"
im = cv2.imread(path, cv2.IMREAD_COLOR)
hsv = cv2.cvtColor(im,cv2.COLOR_BGR2HSV)
```

In [24]:

```
imLessYellow = shift_color(hsv, 240, 30) # yellow = 60, opposite = 60+180 = 24
0
```

In [25]:
```
plt.imshow(cv2.cvtColor(im, cv2.COLOR_BGR2RGB))
```

Out[25]:
```
<matplotlib.image.AxesImage at 0x1d7ed22ac88>
```



In [26]:
```
plt.imshow(cv2.cvtColor(imLessYellow, cv2.COLOR_HSV2RGB))
```

Out[26]:
```
<matplotlib.image.AxesImage at 0x1d7ed2960f0>
```