Programming Project #1: Hybrid Images

CS445: Computational Photography - Spring 2020

Part I: Hybrid Images

In [1]:
```
import cv2

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

import utils
```

In [2]:
```
%matplotlib notebook
import matplotlib.pyplot as plt
```

In [3]:
```
im1_file = './happy.jpg'
im2_file = './sad.jpg'

im1 = cv2.imread(im1_file, cv2.IMREAD_GRAYSCALE)
im2 = cv2.imread(im2_file, cv2.IMREAD_GRAYSCALE)
```

In [4]:
```
pts_im1 = utils.prompt_eye_selection(im1)
```

In [5]:
```
pts_im2 = utils.prompt_eye_selection(im2)
```

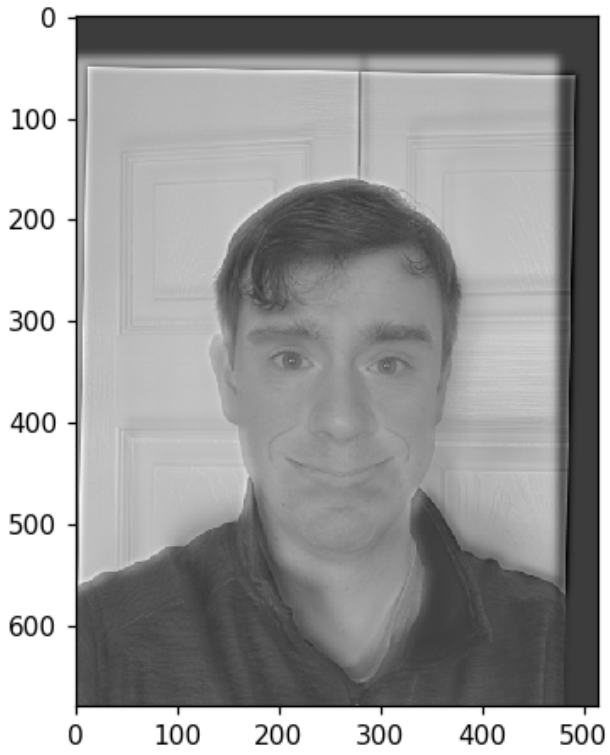
In [6]:
```
im1, im2 = utils.align_images(im1_file, im2_file,pts_im1,pts_im2,save_im
```

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, cutoff_low, cutoff_high):
    '''
    Inputs:
        im1:    RGB (height x width x 3) or a grayscale (height x width)
                as a numpy array.
        im2:    RGB (height x width x 3) or a grayscale (height x width)
                as a numpy array.
        cutoff_low: standard deviation for the low-pass filter
        cutoff_high: standard deviation for the high-pass filter

    Output:
        Return the combination of both images, one filtered with a low-p
        and the other with a high-pass filter.
    '''
    #https://stackoverflow.com/questions/47369579/how-to-get-the-gaussia

    sigma_low = 1./(2*np.pi*cutoff_low)
    sigma_high = 1./(2*np.pi*cutoff_high)

    fil_low = cv2.getGaussianKernel(25,sigma_low)
    fil_high = cv2.getGaussianKernel(25,sigma_high)
    fil_low = np.dot(fil_low,fil_low.T)
    fil_high = np.dot(fil_high,fil_high.T)
    im1_low = cv2.filter2D(im1, -1, fil_low)
    im2_low = cv2.filter2D(im2, -1, fil_high)
    return im2_low + im1 - im1_low, im1 - im1_low, im2_low
```

In [11]:
```
#https://docs.opencv.org/2.4/modules/imgproc/doc/filtering.html#Mat%20ge
ksize_low = 20
ksize_high = 25
sigma_low = 0.3*((ksize_low-1)*0.5 - 1) + 0.8
sigma_high = 0.3*((ksize_high-1)*0.5 - 1) + 0.8
cutoff_low = 1./(2*np.pi*sigma_low)
cutoff_high = 1./(2*np.pi*sigma_high)

im_hybrid, im_high, im_low = hybridImage(im1, im2, cutoff_low, cutoff_hi

plt.close()
plt.imshow(im_hybrid, cmap='gray')
```



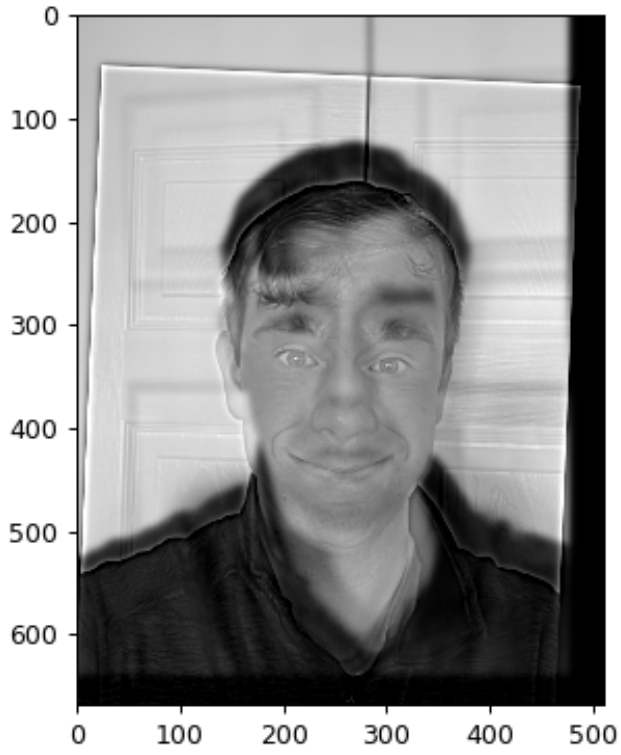
Out[11]: <matplotlib.image.AxesImage at 0x7ff9944832d0>

Below is the final cropped hybrid image. The foreground (up close) image is my smileing and the background (far away) image is me frowning. The foreground image contains only high frequency imformation and the backround image contains only low frequencies. The hybrid image is created by simply adding these two images together.

In [12]:
```
# 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)
```

This figure is an example of a missaligned mistake

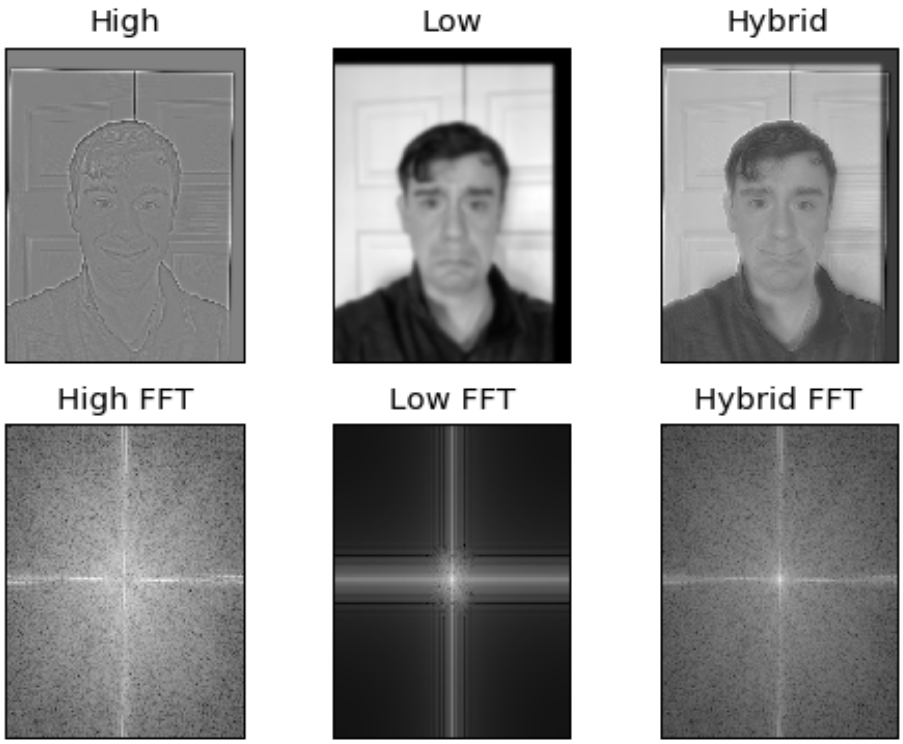
In [13]:
```
im_file = './mistake.png'
im1 = cv2.imread(im_file, cv2.IMREAD_GRAYSCALE)
plt.close()
plt.imshow(im1, cmap='gray')
```



Out[13]: <matplotlib.image.AxesImage at 0x7ff994381b50>

These figures show the high frequency, low frequency, hybrid images and their cooresponding frequency plots.

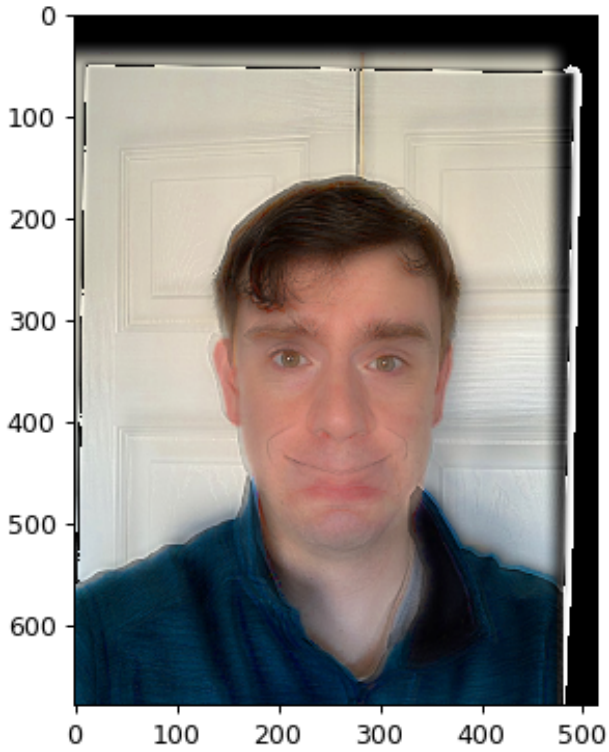
In [14]:
```
plt.close()
fig, axes = plt.subplots(2, 3)
axes[0,0].imshow(im_high,cmap='gray')
axes[0,0].set_title('High'), axes[0,0].set_xticks([]), axes[0,0].set_yti
axes[0,1].imshow(im_low,cmap='gray')
axes[0,1].set_title('Low'), axes[0,1].set_xticks([]), axes[0,1].set_ytic
axes[0,2].imshow(im_hybrid,cmap='gray')
axes[0,2].set_title('Hybrid'), axes[0,2].set_xticks([]), axes[0,2].set_y

axes[1,0].imshow(np.log(np.abs(np.fft.fftshift(np.fft.fft2(im_high)))),c
axes[1,0].set_title('High FFT'), axes[1,0].set_xticks([]), axes[1,0].set
axes[1,1].imshow(np.log(np.abs(np.fft.fftshift(np.fft.fft2(im_low)))),cm
axes[1,1].set_title('Low FFT'), axes[1,1].set_xticks([]), axes[1,1].set_
axes[1,2].imshow(np.log(np.abs(np.fft.fftshift(np.fft.fft2(im_hybrid))))
axes[1,2].set_title('Hybrid FFT'), axes[1,2].set_xticks([]), axes[1,2].s
```



Color Hybrid Image (Bells and Whistles)

Changing emotion hybrid image example with color (bells and wistles). It seems best to use the color on the low frequency image. Using the color from the high frequency image seems to overwhelm the low frequencies.

In [15]:
```
im1_file = './happy.jpg'
im2_file = './sad.jpg'

im1, im2 = utils.align_images(im1_file, im2_file,pts_im1,pts_im2,save_im

hsv1 = cv2.cvtColor(im1,cv2.COLOR_BGR2HSV)
hsv2 = cv2.cvtColor(im2,cv2.COLOR_BGR2HSV)
[h1,s1,v1] = [hsv1[:,:,0],hsv1[:,:,1],hsv1[:,:,2]]
[h2,s2,v2] = [hsv2[:,:,0],hsv2[:,:,1],hsv2[:,:,2]]

ksize_low = 15
ksize_high = 50
sigma_low = 0.3*((ksize_low-1)*0.5 - 1) + 0.8
sigma_high = 0.3*((ksize_high-1)*0.5 - 1) + 0.8
cutoff_low = 1./(2*np.pi*sigma_low)
cutoff_high = 1./(2*np.pi*sigma_high)

v_hybrid, v_high, v_low = hybridImage(v1, v2, cutoff_low, cutoff_high)

hsv_hyb = hsv2
hsv_hyb[:,:,2] = v_hybrid
rgb = cv2.cvtColor(hsv_hyb,cv2.COLOR_HSV2RGB)
plt.close()
plt.imshow(rgb)
```



Out[15]: <matplotlib.image.AxesImage at 0x7ff9900b2350>

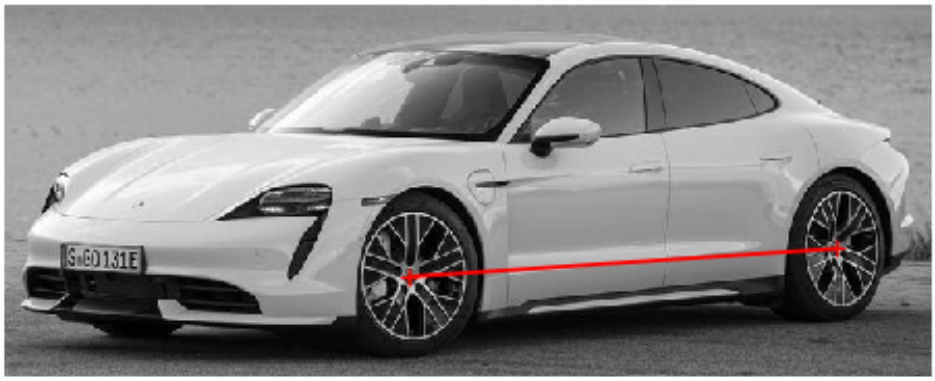
Another example of hybrid images fading a Tesla into a Porsche. Here the same

alignment tool was used to align the cars except that thw center of the wheels were used for allignment rather than the center of the eyes.

In [16]:
```
im1_file = './tesla.jpg'
im2_file = './porsche.jpg'

im1 = cv2.imread(im1_file, cv2.IMREAD_GRAYSCALE)
im2 = cv2.imread(im2_file, cv2.IMREAD_GRAYSCALE)
```

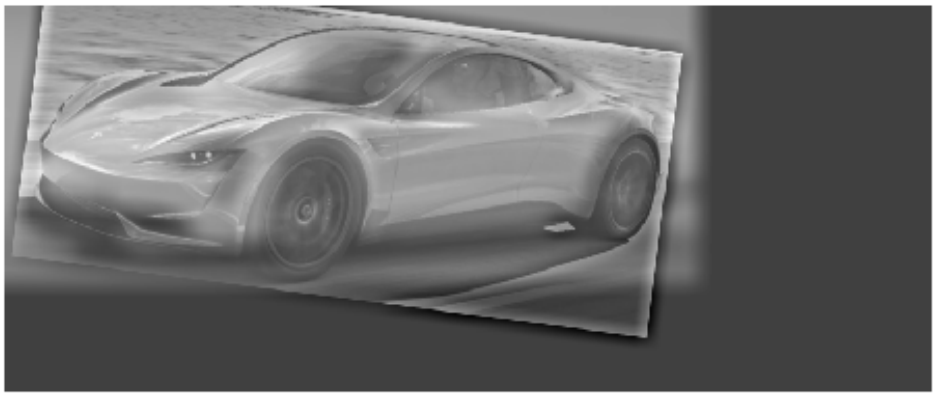
In [17]:
```
pts_im1 = utils.prompt_eye_selection(im1)
```

In [18]:
```
pts_im2 = utils.prompt_eye_selection(im2)
```



Type *Markdown* and LaTeX: α^2

In [20]:
```
im1, im2 = utils.align_images(im1_file, im2_file,pts_im1,pts_im2,save_im
im1 = cv2.cvtColor(im1, cv2.COLOR_BGR2GRAY) / 255.0
im2 = cv2.cvtColor(im2, cv2.COLOR_BGR2GRAY) / 255.0

#https://docs.opencv.org/2.4/modules/imgproc/doc/filtering.html#Mat%20ge
ksize_low = 75
ksize_high = 75
sigma_low = 0.3*((ksize_low-1)*0.5 - 1) + 0.8
sigma_high = 0.3*((ksize_high-1)*0.5 - 1) + 0.8
cutoff_low = 1./(2*np.pi*sigma_low)
cutoff_high = 1./(2*np.pi*sigma_high)
im_hybrid, im_high, im_low = hybridImage(im1, im2, cutoff_low, cutoff_hi

plt.close()
cropped_object = utils.interactive_crop(im_hybrid)
```



Type *Markdown* and LaTeX: α^2

Part II: Image Enhancement

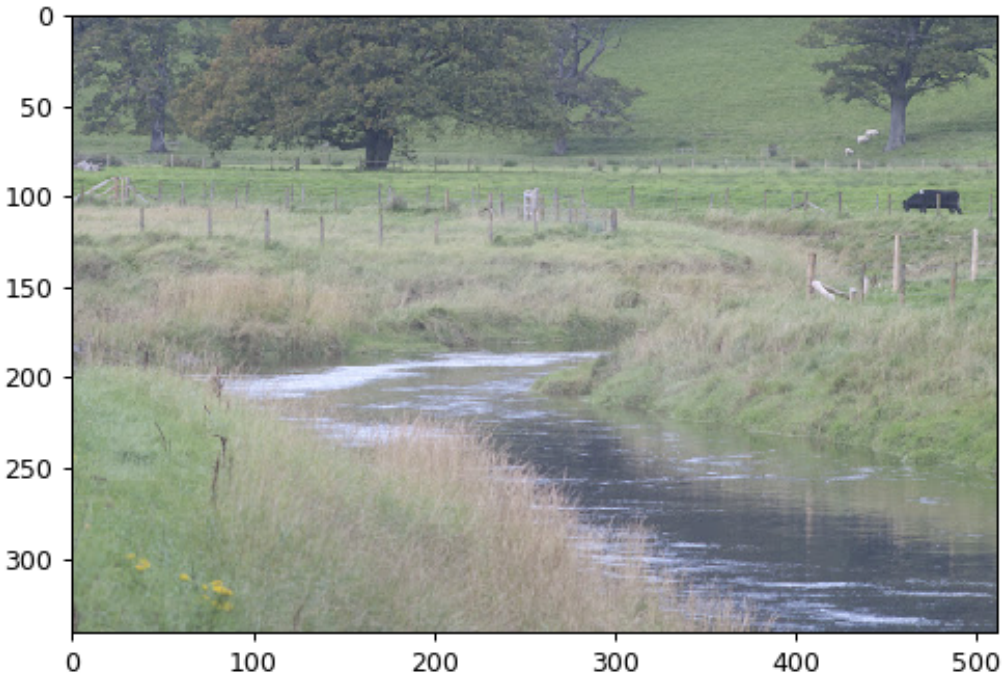
Two out of three types of image enhancement are required. Choose a good image to showcase each type and implement a method. This code doesn't rely on the hybrid image part.

Contrast enhancement

In [21]:
```
def hist_eq(im,alpha):
    returnim = im
    valuehist = np.histogram(im, bins=np.arange(256))
    N = im.size
    c = np.cumsum(valuehist[0])
    for i in range(255):
        returnim = np.where(returnim==i, alpha*c[i]*255./N + (1.-alpha)*
        #np.put(returnim,np.argwhere(returnim==i),c[i]*255./N)
    return returnim
```

Original Image:

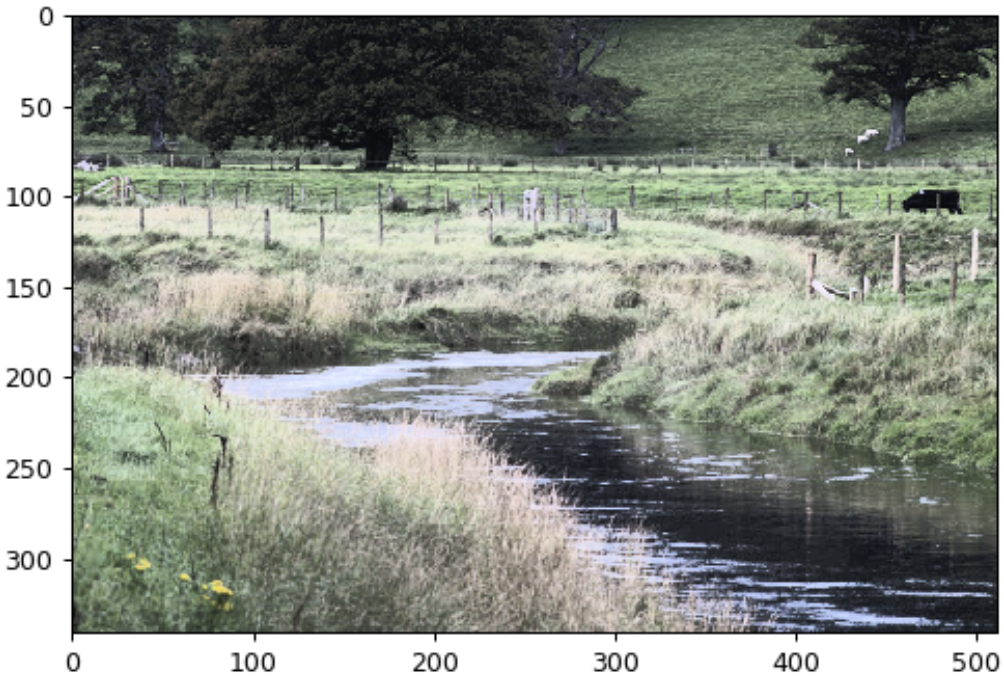
In [22]:
```
bc = './bad_contrast.jpg'

img = cv2.imread(bc)
hsv = cv2.cvtColor(img,cv2.COLOR_BGR2HSV)
rgb = cv2.cvtColor(hsv,cv2.COLOR_HSV2RGB)

plt.close()
plt.imshow(rgb)
```



Out[22]: <matplotlib.image.AxesImage at 0x7ff99298f0d0>

Contrast is corrected by performing histogram equalization on the value channel. Histogram equalization seemd to be the best approach to utilize the full range of intensities in the image.

In [23]:
```
[h,s,v] = [hsv[:,:,0],hsv[:,:,1],hsv[:,:,2]]

veq = hist_eq(v,0.8)
hsv_eq = hsv
hsv_eq[:,:,2] = veq

rgb = cv2.cvtColor(hsv_eq,cv2.COLOR_HSV2RGB)
plt.close()
plt.imshow(rgb)
```

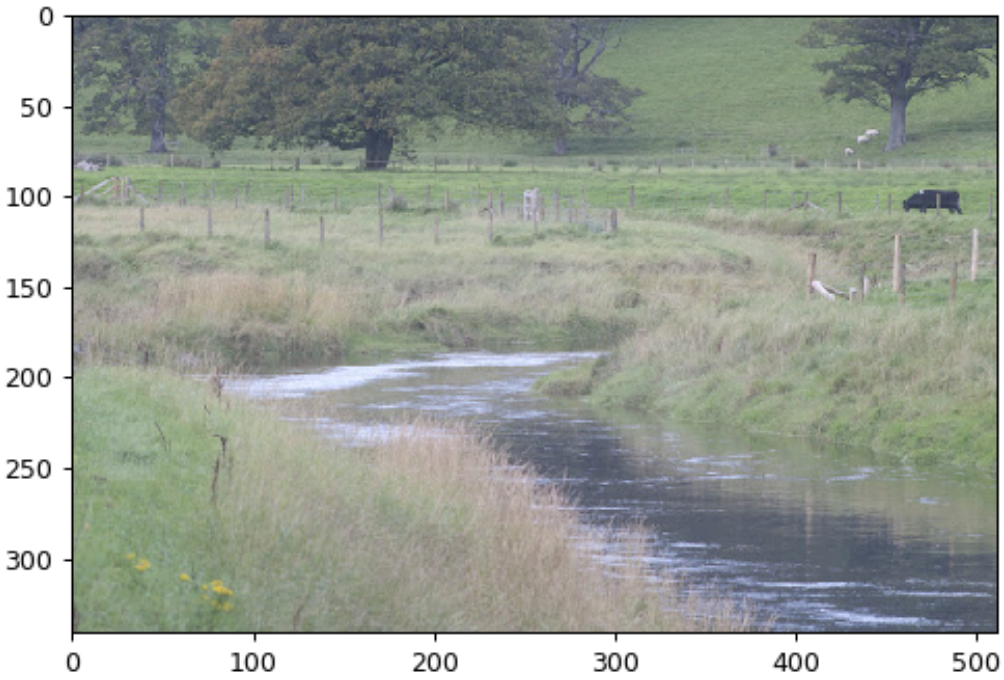


Out[23]: <matplotlib.image.AxesImage at 0x7ff978fd8290>

Color enhancement

Original Image:

In [24]:
```
bc = './bad_contrast.jpg'

img = cv2.imread(bc)
hsv = cv2.cvtColor(img,cv2.COLOR_BGR2HSV)
rgb = cv2.cvtColor(hsv,cv2.COLOR_HSV2RGB)

plt.close()
plt.imshow(rgb)
```



Out[24]: `<matplotlib.image.AxesImage at 0x7ff978ff0510>`

The colors are made more vivid by performing a histogram equalization on the saturation channel of the image.

In [25]:
```
[h,s,v] = [hsv[:,:,0],hsv[:,:,1],hsv[:,:,2]]

sev = hist_eq(s,0.5)
hsv_eq = hsv
hsv_eq[:,:,1] = sev
rgb = cv2.cvtColor(hsv_eq,cv2.COLOR_HSV2RGB)
plt.close()
plt.imshow(rgb)
```

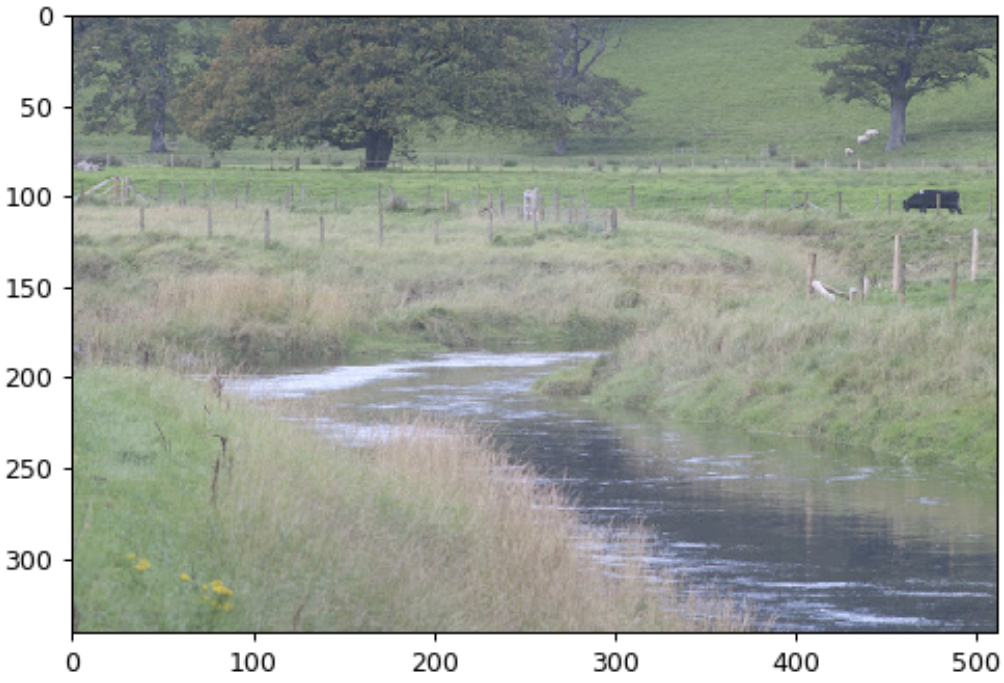
Out[25]: <matplotlib.image.AxesImage at 0x7ff978f5a910>

Color shift (Bells and Whistles)

In [26]:
```
def gamma(im,gamma):
    returnim = im/255.
    returnim = np.power(returnim,gamma)
    return returnim*255
```

Original Image:

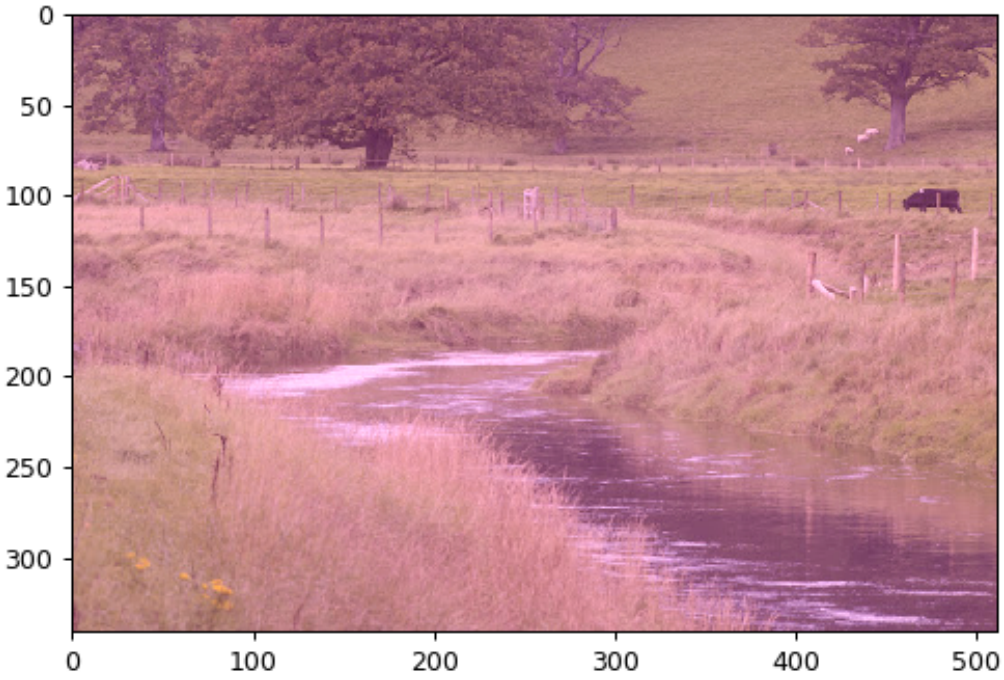
In [27]:
```
bc = './bad_contrast.jpg'
img = cv2.imread(bc)
lab = cv2.cvtColor(img,cv2.COLOR_BGR2LAB)
rgb = cv2.cvtColor(lab,cv2.COLOR_LAB2RGB)

plt.close()
plt.imshow(rgb)
```



Out[27]:
```
<matplotlib.image.AxesImage at 0x7ff978ebdd50>
```

Make the immage more red by applying a gamma adjustment on the a channel in the LAB colorspace.

In [28]:
```
[l,a,b] = [lab[:,:,0],lab[:,:,1],lab[:,:,2]]
ag = gamma(a,.7)
lab_shift = lab
lab_shift[:,:,1] = ag
rgb = cv2.cvtColor(lab_shift,cv2.COLOR_LAB2RGB)

plt.close()
plt.imshow(rgb)
```

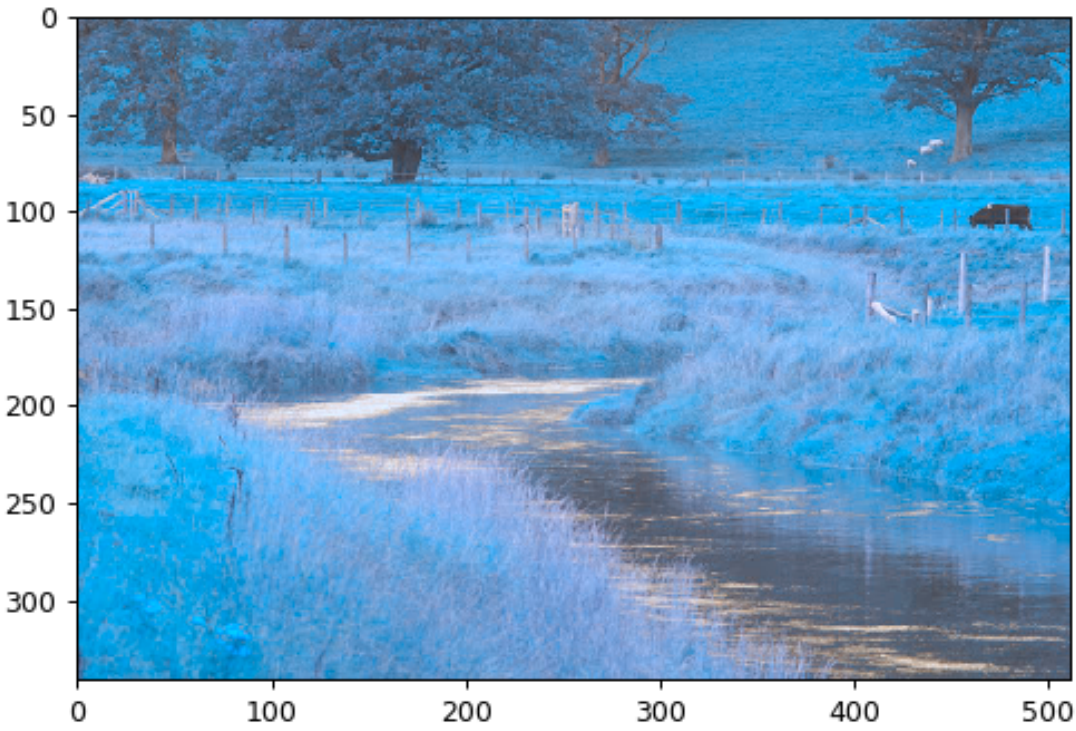


Out[28]: <matplotlib.image.AxesImage at 0x7ff978eb4390>

In this image the color is made less yellow by applying a negative gamma adjustment on the b channel in the LAB colorspace.

In [29]:
```
lab = cv2.cvtColor(img,cv2.COLOR_BGR2LAB)
[l,a,b] = [lab[:,:,0],lab[:,:,1],lab[:,:,2]]
bg = gamma(b,-0.5)
lab_shift = lab
lab_shift[:,:,2] = bg
rgb = cv2.cvtColor(lab_shift,cv2.COLOR_LAB2RGB)

plt.close()
plt.imshow(rgb)
```

Figure 1



Reset origina

Out[29]: <matplotlib.image.AxesImage at 0x7ff978e18d90>

I belive I should receive all 100 points for the regular assignment and 15 points of bells and whistles. I completed all three image enhancement tasks (10 points) and the hybrid image in color (5 points).