Programming Project #2: Image Quilting

CS445: Computational Photography - Fall 2019

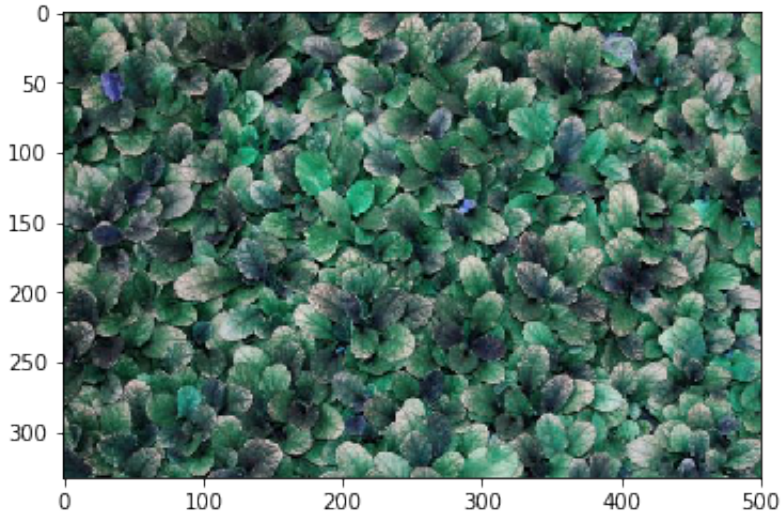
In [1]:
```
import cv2
import numpy as np
import matplotlib.pyplot as plt
%matplotlib notebook
import utils
import os
import random
```

In [2]:
```
from utils import cut # default cut function for seam finding section
```

Part I: Randomly Sampled Texture (10 pts)

In [3]:
```
sample_img_dir = 'samples/2.jpg' # feel free to change
sample_img = None
if os.path.exists(sample_img_dir):
    sample_img = cv2.imread(sample_img_dir)

plt.imshow(sample_img)
```

Out[3]: <matplotlib.image.AxesImage at 0x10cdc5320>



In [4]:
```
def quilt_random(sample, out_size, patch_size):
    """
    Randomly samples square patches of size patchsize from sample in orde

    :param sample: numpy.ndarray   The image you read from sample directo
    :param out_size: int            The width of the square output image
    :param patch_size: int          The width of the square sample patch
    :return: numpy.ndarray
    """

    result = np.zeros((out_size, out_size, 3))

    patches = out_size//patch_size
    (r, c, _) = sample.shape
    row_range = r-patch_size
    col_range = c-patch_size

    for i in range(patches):
        for j in range(patches):
            loc_r = random.randint(0, row_range)
            loc_c = random.randint(0, col_range)

            result[i*patch_size:(i+1)*patch_size, j*patch_size:(j+1)*patc
                = sample[loc_r:loc_r+patch_size, loc_c:loc_c+patch_size,

    return result
```

In [5]:
```
out_size = 600  # feel free to change to debug
patch_size = 40 # feel free to change to debug
print(sample_img.shape)
res = quilt_random(sample_img, out_size, patch_size)
res = res.astype(np.uint8)

res = cv2.cvtColor(res, cv2.COLOR_BGR2RGB)

fig, axes = plt.subplots(1,1)
axes.imshow(res)
axes.set_xticks([])
axes.set_yticks([])
```

```
(333, 500, 3)
```

Out[5]:
```
[]
```

Part II: Overlapping Patches (30 pts)

In [4]:
```
def ssd_patch(T, M, I):
    T.astype(np.float64)
    M.astype(np.float64)
    I.astype(np.float64)
    T = T/15
    I = I/15

    channel1 = ((M[:,:,0]*T[:,:,0])**2).sum() - 2 * cv2.filter2D(I[:,:,0]
                kernel = M[:,:,0]*T[:,:,0]) + cv2.filter2D(I[:,:,0] ** 2,
    channel2 = ((M[:,:,1]*T[:,:,1])**2).sum() - 2 * cv2.filter2D(I[:,:,1]
                kernel = M[:,:,1]*T[:,:,1]) + cv2.filter2D(I[:,:,1] ** 2,
    channel3 = ((M[:,:,2]*T[:,:,2])**2).sum() - 2 * cv2.filter2D(I[:,:,2]
                kernel = M[:,:,2]*T[:,:,2]) + cv2.filter2D(I[:,:,2] ** 2,
    (r, c) = channel1.shape

    ssd = np.zeros((r, c))
    ssd[:,:] = channel1 + channel2 + channel3


    return np.absolute(ssd[:,:])
```

In [5]:
```
def choose_sample(cost, tol):
    minc = np.amin(cost)
    row, col = np.where(cost <= minc*(1+tol))
    index = list(zip(list(row), list(col)))
    return random.choice(index)
```

In [8]:
```
def quilt_simple(sample, out_size, patch_size, overlap, tol):
    """
    Randomly samples square patches of size patchsize from sample in orde
    Feel free to add function parameters
    :param sample: numpy.ndarray
    :param out_size: int
    :param patch_size: int
    :param overlap: int
    :param tol: int
    :return: numpy.ndarray
    """
    # Todo
    mask_left = np.zeros((patch_size, patch_size, 3))
    mask_left[:, :overlap,:] = 1

    mask_top = np.zeros((patch_size, patch_size, 3))
    mask_top[:overlap, :, :] = 1

    mask_other = np.zeros((patch_size, patch_size, 3))
    mask_other[:, :overlap, :] = 1
    mask_other[:overlap, :, :] = 1
```

```
    mask_other[overlap:, :, :] = 1

    result = np.zeros((out_size, out_size, 3))
    rows = (out_size-overlap) // (patch_size-overlap)
    cols = (out_size-overlap) // (patch_size-overlap)

    loc_r = random.randint(0, sample.shape[0]-patch_size)
    loc_c = random.randint(0, sample.shape[1]-patch_size)

    result[:patch_size, :patch_size, :] = sample[loc_r:loc_r+patch_size,

    for i in range(1, rows):
        ssd = ssd_patch(result[i*(patch_size-overlap):i*(patch_size-overl
                               : patch_size, :], mask_top, sample)
        ssd = ssd[patch_size//2:-patch_size//2, patch_size//2:-patch_size
        (row, col) = choose_sample(ssd, tol)
        #plt.imshow(result[i*(patch_size-overlap):i*(patch_size-overlap)+
        result[i*(patch_size-overlap):i*(patch_size-overlap)+patch_size,
            sample[row:row+patch_size, col:col+patch_size,:].copy()

    for i in range(1, cols):
        ssd = ssd_patch(result[:patch_size, i*(patch_size-overlap):i*(pat
                               :], mask_left, sample)
        ssd = ssd[patch_size//2:-patch_size//2, patch_size//2:-patch_size
        (row, col) = choose_sample(ssd, tol)
        result[: patch_size, i*(patch_size-overlap):i*(patch_size-overlap
            sample[row:row+patch_size, col:col+patch_size,:].copy()

    for i in range(1, cols):
        for j in range(1, rows):
            ssd = ssd_patch(result[i*(patch_size-overlap):i*(patch_size-o
                                   j*(patch_size-overlap):j*(patch_size-o
                                   mask_other, sample)
            ssd = ssd[patch_size//2:-patch_size//2, patch_size//2:-patch_
            (row, col) = choose_sample(ssd, tol)
            result[i*(patch_size-overlap):i*(patch_size-overlap)+patch_si
                   j*(patch_size-overlap):j*(patch_size-overlap)+patch_si
                    sample[row:row+patch_size, col:col+patch_size,:].copy

    return result
```

In [9]:
```
res = quilt_simple(sample_img, 610, 40, 10, 0.001) #feel free to change p

res = res.astype(np.uint8)

res = cv2.cvtColor(res, cv2.COLOR_BGR2RGB)

fig, axes = plt.subplots(1,1)
axes.imshow(res)
axes.set_xticks([])
axes.set_yticks([])
```

Out[9]: []

Part III: Seam Finding (20 pts)

In [10]:
```
# optional or use cut(err_patch) directly
def customized_cut(bndcost):
    pass
```

In [6]:
```
def quilt_cut(sample, out_size, patch_size, overlap, tol):
    """
    Samples square patches of size patchsize from sample using seam findi
    Feel free to add function parameters
    :param sample: numpy.ndarray
    :param out_size: int
    :param patch_size: int
    :param overlap: int
    :param tol: int
    :return: numpy.ndarray
    """
    mask_left = np.zeros((patch_size, patch_size, 3))
    mask_left[:, :overlap,:] = 1
```

```
    mask_top = np.zeros((patch_size, patch_size, 3))
    mask_top[:overlap, :, :] = 1

    mask_other = np.zeros((patch_size, patch_size, 3))
    mask_other[:, :overlap, :] = 1
    mask_other[:overlap, :, :] = 1

    ones1 = np.ones((overlap, patch_size, 3))
    ones2 = np.ones((patch_size, overlap, 3))

    result = np.zeros((out_size, out_size, 3))
    rows = (out_size-overlap) // (patch_size-overlap)
    cols = (out_size-overlap) // (patch_size-overlap)

    loc_r = random.randint(0, sample.shape[0]-patch_size)
    loc_c = random.randint(0, sample.shape[1]-patch_size)

    result[:patch_size, :patch_size, :] = sample[loc_r:loc_r+patch_size,

    for i in range(1, rows):

        replace = result[i*(patch_size-overlap):i*(patch_size-overlap)+pa
        ssd = ssd_patch(replace, mask_top, sample)
        ssd = ssd[patch_size//2:-patch_size//2, patch_size//2:-patch_size
        (row, col) = choose_sample(ssd, tol)
        new_patch = sample[row:row+patch_size, col:col+patch_size,:].copy

        #diff = ssd_patch(new_patch[:overlap, :patch_size, :], replace[:o

        diff = replace[:overlap,: patch_size, :]**2 - new_patch[:overlap,
        diff = diff[:,:,0]+diff[:,:,1]+diff[:,:,2]

        mask = cut(diff)

        mask = mask.astype(np.uint8)

        new_patch[:overlap,:patch_size,0] *= mask
        new_patch[:overlap,:patch_size,1] *= mask
        new_patch[:overlap,:patch_size,2] *= mask

        inv_mask = np.ones(mask.shape)-mask

        replace[:overlap,:patch_size,0] *= inv_mask
        replace[:overlap,:patch_size,1] *= inv_mask
        replace[:overlap,:patch_size,2] *= inv_mask

        replace += new_patch

    for i in range(1, cols):
```

```
        replace = result[:patch_size, i*(patch_size-overlap):i*(patch_siz
        ssd = ssd_patch(replace, mask_left, sample)
        ssd = ssd[patch_size//2:-patch_size//2, patch_size//2:-patch_size
        (row, col) = choose_sample(ssd, tol)
        new_patch = sample[row:row+patch_size, col:col+patch_size,:].copy

        diff = replace[: patch_size,:overlap, :]**2 - new_patch[:patch_si
        diff = diff[:,:,0]+diff[:,:,1]+diff[:,:,2]
        #diff = ssd_patch(new_patch[:patch_size,:overlap, :], replace[: p
        mask = cut(diff)

        mask = mask.astype(np.uint8)

        new_patch[:patch_size,:overlap,0] *= mask
        new_patch[:patch_size,:overlap,1] *= mask
        new_patch[:patch_size,:overlap,2] *= mask

        inv_mask = np.ones(mask.shape)-mask

        replace[:patch_size,:overlap,0] *= inv_mask
        replace[:patch_size,:overlap,1] *= inv_mask
        replace[:patch_size,:overlap,2] *= inv_mask



        replace += new_patch


    for i in range(1, cols):
        for j in range(1, rows):
            replace = result[i*(patch_size-overlap):i*(patch_size-overlap
                                    j*(patch_size-overlap):j*(patch_size-o
            ssd = ssd_patch(replace, mask_other, sample)
            ssd = ssd[patch_size//2:-patch_size//2, patch_size//2:-patch_
            (row, col) = choose_sample(ssd, tol)
            new_patch = sample[row:row+patch_size, col:col+patch_size,:].

            diff = replace[:overlap,: patch_size, :]**2 - new_patch[:over
            diff = diff[:,:,0]+diff[:,:,1]+diff[:,:,2]
            #diff = ssd_patch(new_patch[:overlap, :patch_size, :], replac
            mask1 = cut(diff)


            diff = replace[: patch_size,:overlap, :]**2 - new_patch[:patc
            diff = diff[:,:,0]+diff[:,:,1]+diff[:,:,2]
            #diff = ssd_patch(new_patch[:patch_size,:overlap, :], replace
            mask2 = cut(diff)


            mask_combined = np.ones((patch_size, patch_size))
            mask_combined[:overlap,:patch_size] *= mask1
```

```
            mask_combined[:overlap,:patch_size] = mask1

            mask_combined[:patch_size,:overlap] *= mask2

            mask_combined = mask_combined.astype(np.uint8)


            new_patch[:,:,0] *= mask_combined
            new_patch[:,:,1] *= mask_combined
            new_patch[:,:,2] *= mask_combined

            inv_mask = np.ones(mask_combined.shape)-mask_combined

            replace[:, :,0] *= inv_mask
            replace[:,:,1] *= inv_mask
            replace[:,:,2] *= inv_mask

            replace += new_patch


    return result
```

In [11]:
```
res = quilt_cut(sample_img, 610, 40, 10, 0.001)

res = res.astype(np.uint8)

res = cv2.cvtColor(res, cv2.COLOR_BGR2RGB)

fig, axes = plt.subplots(1,1)
axes.imshow(res)
axes.set_title('seam finding')
axes.set_xticks([])
axes.set_yticks([])
```

Out[11]: []

In [12]:
```
def plot_overlap(sample, patch_size, overlap, tol):
    mask_top = np.zeros((patch_size, patch_size, 3))
    mask_top[:overlap, :, :] = 1

    result = np.zeros((patch_size, patch_size*2-overlap, 3))

    loc_r = random.randint(0, sample.shape[0]-patch_size)
    loc_c = random.randint(0, sample.shape[1]-patch_size)

    result[:patch_size, :patch_size, :] = sample[loc_r:loc_r+patch_size,

    replace = result[:patch_size, : patch_size, :]
    ssd = ssd_patch(replace, mask_top, sample)
    ssd = ssd[patch_size//2:-patch_size//2, patch_size//2:-patch_size//2]
    (row, col) = choose_sample(ssd, tol)
    new_patch = sample[row:row+patch_size, col:col+patch_size,:].copy()

        #diff = ssd_patch(new_patch[:overlap, :patch_size, :], replace[:o


    diff = replace[:overlap,: patch_size, :]**2 - new_patch[:overlap, :pa
    diff = diff[:,:,0]+diff[:,:,1]+diff[:,:,2]

    mask, path = cut(diff)

    fig, axes = plt.subplots(1,3)
    axes[0].imshow(cv2.cvtColor(replace[:overlap,: patch_size, :].astype(
    axes[0].set_xticks([])
    axes[0].set_yticks([])
    axes[1].imshow(cv2.cvtColor(new_patch[:overlap, :patch_size, :].astyp
    axes[1].set_xticks([])
    axes[1].set_yticks([])
    axes[2].imshow(np.absolute(diff/255).astype(np.uint8))
    axes[2].plot(np.linspace(0, 39, num=40), path-1, '-', linewidth=2, co
    axes[2].set_xticks([])
    axes[2].set_yticks([])
```

In [13]:
```
plot_overlap(sample_img, 40, 20, 0.9)
```

part IV: Texture Transfer (30 pts)

In [12]:
```
def texture_transfer(sample, target, alpha):
    """
```

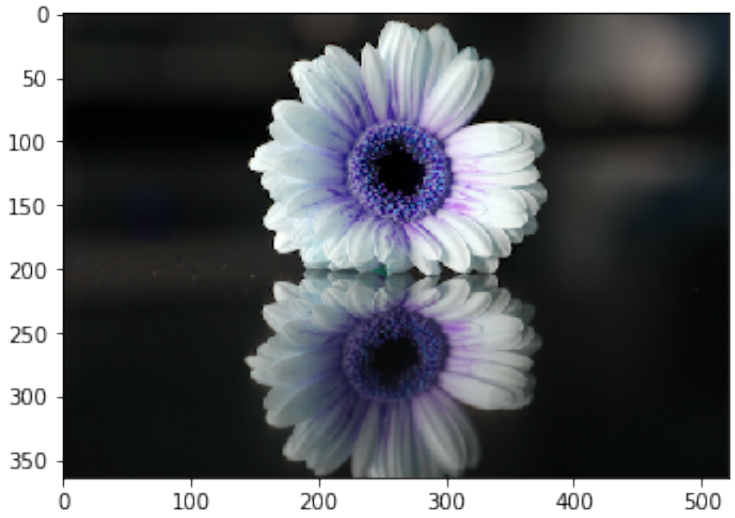
```
    Feel free to add function parameters
    """
    (r, c, _) = target.shape
    p_size = 15
    tol = 0.0001
    overlap = 3

    mask_left = np.zeros((p_size, p_size, 3))
    mask_left[:, :overlap,:] = 1

    mask_top = np.zeros((p_size, p_size, 3))
    mask_top[:overlap, :, :] = 1

    mask_other = np.zeros((p_size, p_size, 3))
    mask_other[:, :overlap, :] = 1
    mask_other[:overlap, :, :] = 1

    ones = np.ones((p_size, p_size, 3))

    result = np.zeros((r, c, 3))
    rows = (r-overlap) // (p_size-overlap)
    cols = (c-overlap) // (p_size-overlap)

    '''
    loc_r = random.randint(0, sample.shape[0]-patch_size)
    loc_c = random.randint(0, sample.shape[1]-patch_size)
    '''

    #result[:patch_size, :patch_size, :] = sample[loc_r:loc_r+patch_size,

    for i in range(0, rows):

        replace = result[i*(p_size-overlap):i*(p_size-overlap)+p_size, :
        target_patch = target[i*(p_size-overlap):i*(p_size-overlap)+p_siz
        ssd_overlap = ssd_patch(replace, mask_top, sample)
        ssd_target = ssd_patch(target_patch, ones, sample)
        ssd_overlap = ssd_overlap[p_size//2:-p_size//2, p_size//2:-p_size
        ssd_target = ssd_target[p_size//2:-p_size//2, p_size//2:-p_size//

        (row, col) = choose_sample(ssd_overlap*alpha+ssd_target*(1-alpha)
        new_patch = sample[row:row+p_size, col:col+p_size,:].copy()

        diff = replace[:overlap,: p_size, :] - new_patch[:overlap, :p_siz
        diff = diff[:,:,0]+diff[:,:,1]+diff[:,:,2]
        mask = cut(diff)

        mask = mask.astype(np.uint8)

        new_patch[:overlap,:p_size,0] *= mask
        new_patch[:overlap,:p_size,1] *= mask
```

```
        new_patch[:overlap,:p_size,2] *= mask

        inv_mask = np.ones(mask.shape)-mask

        replace[:overlap,:p_size,0] *= inv_mask
        replace[:overlap,:p_size,1] *= inv_mask
        replace[:overlap,:p_size,2] *= inv_mask

        replace += new_patch

    for i in range(1, cols):
        replace = result[:p_size, i*(p_size-overlap):i*(p_size-overlap)+p
        target_patch = target[:p_size, i*(p_size-overlap):i*(p_size-overl
        ssd_overlap = ssd_patch(replace, mask_left, sample)
        ssd_target = ssd_patch(target_patch, ones, sample)
        ssd_overlap = ssd_overlap[p_size//2:-p_size//2, p_size//2:-p_size
        ssd_target = ssd_target[p_size//2:-p_size//2, p_size//2:-p_size//

        (row, col) = choose_sample(ssd_overlap*alpha+ssd_target*(1-alpha)
        new_patch = sample[row:row+p_size, col:col+p_size,:].copy()

        diff = replace[: p_size,:overlap, :] - new_patch[:p_size,:overlap
        diff = diff[:,:,0]+diff[:,:,1]+diff[:,:,2]
        mask = cut(diff)

        mask = mask.astype(np.uint8)

        new_patch[:p_size,:overlap,0] *= mask
        new_patch[:p_size,:overlap,1] *= mask
        new_patch[:p_size,:overlap,2] *= mask

        inv_mask = np.ones(mask.shape)-mask

        replace[:p_size,:overlap,0] *= inv_mask
        replace[:p_size,:overlap,1] *= inv_mask
        replace[:p_size,:overlap,2] *= inv_mask



        replace += new_patch


    for i in range(1, rows):
        for j in range(1, cols):
            target_patch = target[i*(p_size-overlap):i*(p_size-overlap)+p
                                  j*(p_size-overlap):j*(p_size-overlap)+
            replace = result[i*(p_size-overlap):i*(p_size-overlap)+p_size
                                  j*(p_size-overlap):j*(p_size-overlap)+
```

```
            ssd_overlap = ssd_patch(replace, mask_other, sample)
            ssd_target = ssd_patch(target_patch, ones, sample)
            ssd_overlap = ssd_overlap[p_size//2:-p_size//2, p_size//2:-p_
            ssd_target = ssd_target[p_size//2:-p_size//2, p_size//2:-p_si

            (row, col) = choose_sample(ssd_overlap*alpha+ssd_target*(1-al
            new_patch = sample[row:row+p_size, col:col+p_size,:].copy()

            diff = replace[:overlap,: p_size, :] - new_patch[:overlap, :p
            diff = diff[:,:,0]+diff[:,:,1]+diff[:,:,2]
            mask1 = cut(diff)

            diff = replace[: p_size,:overlap, :] - new_patch[:p_size,:ove
            diff = diff[:,:,0]+diff[:,:,1]+diff[:,:,2]
            mask2 = cut(diff)


            mask_combined = np.ones((p_size, p_size))
            mask_combined[:overlap,:p_size] *= mask1

            mask_combined[:p_size,:overlap] *= mask2

            mask_combined = mask_combined.astype(np.uint8)


            new_patch[:,:,0] *= mask_combined
            new_patch[:,:,1] *= mask_combined
            new_patch[:,:,2] *= mask_combined

            inv_mask = np.ones(mask_combined.shape)-mask_combined

            replace[:, :,0] *= inv_mask
            replace[:,:,1] *= inv_mask
            replace[:,:,2] *= inv_mask

            replace += new_patch


    return result
```

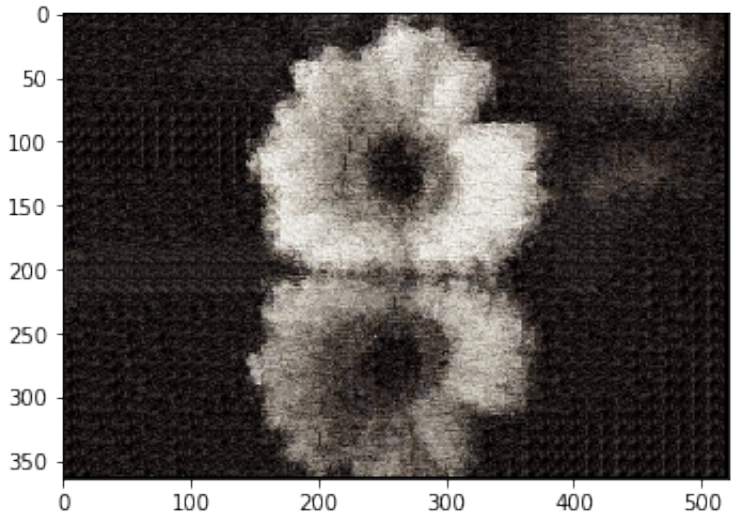
In [13]:
```
img = cv2.imread('samples/5.jpg')
plt.imshow(img)

target = cv2.imread('samples/flower_small.png')
plt.imshow(target)
```

Out[13]: <matplotlib.image.AxesImage at 0x1215ef588>



In [14]:
```
res = texture_transfer(img, target, 0.5)


res = res.astype(np.uint8)
res = cv2.cvtColor(res, cv2.COLOR_BGR2RGB)
plt.imshow(res)
```

Out[14]: <matplotlib.image.AxesImage at 0x12665d0b8>



Bells & Whistles

(10 pts) Create and use your own version of cut.m. To get these points, you should create your own implementation without basing it directly on the provided function (you're on the honor code for this one).

You can simply copy your customized_cut(bndcost) into the box below so that it is easier for us to grade

In [ ]:

(15 pts) Implement the iterative texture transfer method described in the paper. Compare to the non-iterative method for two examples.

In [ ]:

(up to 20 pts) Use a combination of texture transfer and blending to create a face-in-toast image like the one on top. To get full points, you must use some type of blending, such as feathering or Laplacian pyramid blending.

In [ ]:

(up to 40 pts) Extend your method to fill holes of arbitrary shape for image completion. In this case, patches are drawn from other parts of the target image. For the full 40 pts, you should implement a smart priority function (e.g., similar to Criminisi et al.).

In [ ]:

In [ ]:

In [ ]:

In [ ]: