Solution

February 17, 2019

1 Solution for Assignment 2

1.1 Image Mosaicing(Image Stitching)

1.1.1 Problem

Given n images of same scene from different viewpoints, stitch those images together.

1.1.2 Procedure

- Points and Feature Detection
- Matching
- Hommography
- Stitch 2 images

1.1.3 Images

```
1. img1_* => hill
2. img2_* => taj mahal
3. img3_* => cactus
4. img4_* => text
```

```
In [94]: # Imports
         import os
         import cv2
         import numpy as np
         import matplotlib.pyplot as plt

         # Dirs
         test_dir = './test_images/'
         save_dir = './save_images/'
         if not os.path.exists(save_dir):
             os.mkdir(save_dir)


         # Parameters
         MIN_MATCH_COUNT = 40
```

```
% matplotlib inline
```

```
In [214]: # Helper functions
          def display_images(img_list, shape,fig_size=(16,16),is_gray=None):
              """
                  Display multple images using matplotlib
                  @param img_list:=> mxn matrix of images to be displayed
                  @param shape:=> mxn shape
                  @param is_gray:=> mxn matrix, is the i,j th the image grayscaled

                  return None
              """

              if is_gray is None:
                  is_gray = np.zeros(shape)

              m,n = shape
              fig = plt.figure(figsize=fig_size)

              for i in range(m):
                  for j in range(n):
                      ax = fig.add_subplot(m,n,i*n + j+1)
                      if is_gray[i,j] == 1:
                          ax.imshow(img_list[i][j],cmap='gray')
                      else:
                          img_list[i][j] = cv2.resize(img_list[i][j],(200,200))
                          ax.imshow(img_list[i][j])
                      ax.axis('off')
              plt.show()
              return
```

1.2 Step 1 -> Feature Matching

```
In [215]: def ORB_features(img_list):
              """
                  Input: numpy image list
                  Returns list sift keypoints and their discriptors for each image
              """
              orb = cv2.ORB_create()


              kp_list = []
              des_list = []

              for im in img_list:
                  gray = cv2.cvtColor(im, cv2.COLOR_RGB2GRAY)
                  kp, des = orb.detectAndCompute(gray,None)
```

```
            kp_list.append(kp)
            des_list.append(des)

        return kp_list, des_list


    def feature_matching(img_list):

        # create BFMatcher object
        bf = cv2.BFMatcher(cv2.NORM_HAMMING, crossCheck=True)

        # Get features
        kp_list, des_list = ORB_features(img_list)

        # Match descriptors.
        matches = bf.match(des_list[0],des_list[1])
        # Sort them in the order of their distance.
        matches = sorted(matches, key = lambda x:x.distance)[:MIN_MATCH_COUNT]

        draw_params = dict(matchesMask=None,
                           singlePointColor=None,
                           matchColor=(0, 255, 0),
                           flags=2)

        img3 = cv2.drawMatches(img_list[0],kp_list[0],img_list[1],kp_list[1],matches,None,


        return matches,kp_list,des_list
```

1.3 Step 2 -> Homography

For calculating we are using ransac algorithm, best threashold for ransac is obtained at 30% inl

For each iteration we randomly take 4 variables
Homography is a 3x3 matrix as the camera center is assumed to be same for each image
Our objective is the minimize the distance predicted(after transformation using homography) and
Hence we have a formulation simmilar to DLT.
We take the least eigen value vector as the homography in each iteration.
Iteration with least error is the most accurate homography matrix

```
In [216]: def find_homogrpahy(correspondences):
            aList = []
            for corr in correspondences:

                x1 = corr[0]
                x2 = corr[1]
                a2 = [0, 0, 0, -x1[0], -x1[1], -1, x2[1] *x1[0] , x2[1]*x1[1] , x2[1] ]
                a1 = [ -x1[0], -x1[1], -1,  0, 0, 0,  x2[0] * x1[0], x2[0] * x1[1], x2[0] ]
```

```
            aList.append(a1)
            aList.append(a2)

        matrixA = np.array(aList)

        u, d, v = np.linalg.svd(matrixA)

        h = np.reshape(v[8], (3, 3))

        h = h/h[2,2]
        return h

    def geometricDistance(src,dst, h):
        p1 = np.array([src[0],src[1], 1]).T
        estimatep2 = np.dot(h, p1)
        estimatep2 = estimatep2/estimatep2[2]

        p2 = np.matrix([ dst[0], dst[1], 1]).T
        error = p2 - estimatep2
        return np.linalg.norm(error)

    def ransac(src_pts,dst_pts, thresh, dist=5):
        maxInliers = []
        finalH = None
        for i in range(500):
            r4 =  np.random.randint(0,len(src_pts),4)
            randomFour = []
            for x in r4:
                randomFour.append((src_pts[x,0,:], dst_pts[x,0,:] ))

            h = find_homogrpahy(randomFour)

            inliers = []

            for i in range(len(src_pts)):
                d = geometricDistance( src_pts[i,0,:], dst_pts[i,0,:] , h)
                if d < dist:
                    inliers.append(cr)

            if len(inliers) > len(maxInliers):
                maxInliers = inliers
                finalH = h

            if len(maxInliers) > len(src_pts)*thresh:
                break

        return finalH
```

```
In [217]: def calculate_homography(matches,kp_list):

              if len(matches) < MIN_MATCH_COUNT:
                  return None
              best_matches = matches[0:MIN_MATCH_COUNT]
              src_pts = np.float32([ kp_list[0][m.queryIdx].pt for m in best_matches ]).reshape(
              dst_pts = np.float32([ kp_list[1][m.trainIdx].pt for m in best_matches ]).reshape(
              M = ransac(src_pts, dst_pts,0.1,dist=5.0)

              return M

In [219]: def get_transformation(img_list):
              # Print original images
          #     display_images([img_list],(1,2))

              # Feature matching
              matches,kp_list,des_list =  feature_matching(img_list)

              # Homography
              M = calculate_homography(matches,kp_list)

              h,w,c = img_list[0].shape
              pts = np.float32([ [0,0],[0,h-1],[w-1,h-1],[w-1,0] ]).reshape(-1,1,2)
              dst = cv2.perspectiveTransform(pts,M)
              img2 = cv2.polylines(img_list[1].copy(),[np.int32(dst)],True,255,3, cv2.LINE_AA)

              h,w,c = img_list[1].shape
              pts = np.float32([ [0,0],[0,h-1],[w-1,h-1],[w-1,0] ]).reshape(-1,1,2)
              dst = cv2.perspectiveTransform(pts,np.linalg.inv(M))
              img1 = cv2.polylines(img_list[0].copy(),[np.int32(dst)],True,255,3, cv2.LINE_AA)

              # Print original images
              display_images([[img1,img2]],(1,2))

              return M
```

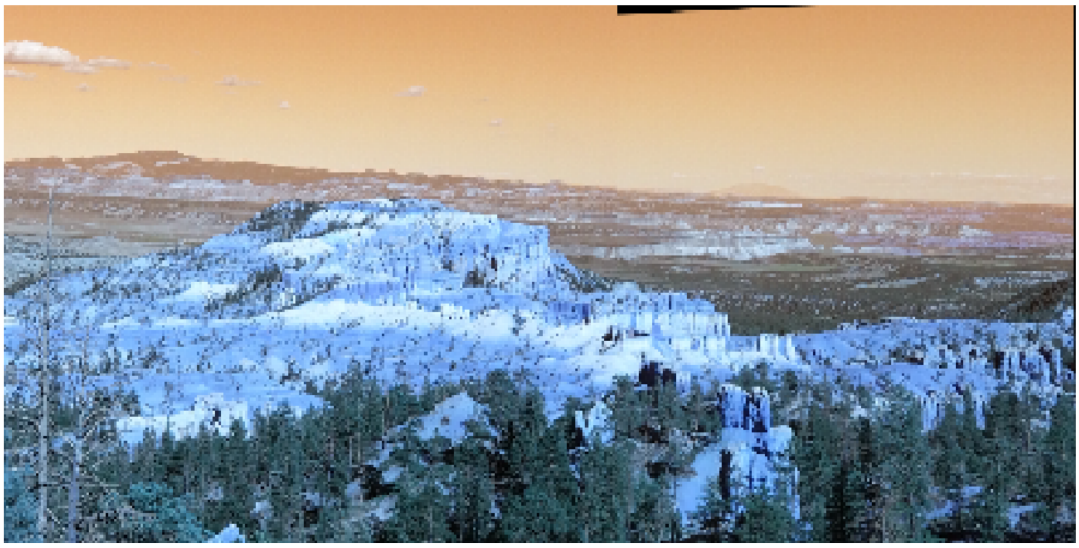
1.4 Step3 -> Stitch Images

```
In [220]: def stitching(img_list,M):
              h,w,c = img_list[0].shape
              dst = cv2.warpPerspective(img_list[1],np.linalg.inv(M),(2*w,2*h))
              dst[0 : h , 0: w,:] = img_list[0]
              return dst

In [221]: def stitching(img_list,M):
              dst = cv2.warpPerspective(img_list[1],np.linalg.inv(M),(img_list[0].shape[1]+img_l
              dst[0:img_list[0].shape[0],0:img_list[0].shape[1],:] = img_list[0]
              return dst
```

In [222]:
```
# Remove black region from width
def remove_black(final_img):
    r = np.where(np.sum(final_img,(0,2)) == 0)[0][0]
    final_img = final_img[:,0:r,:]
    return final_img
```

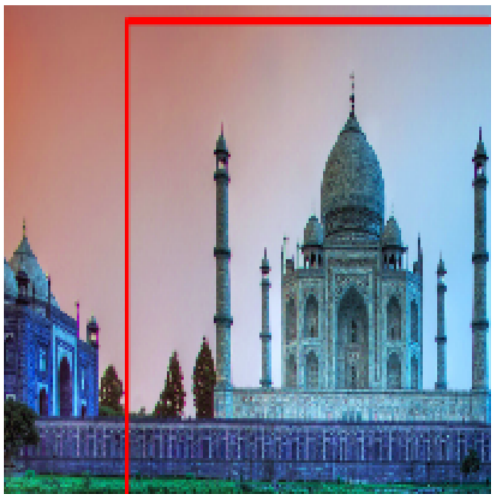
1.5 Show Results

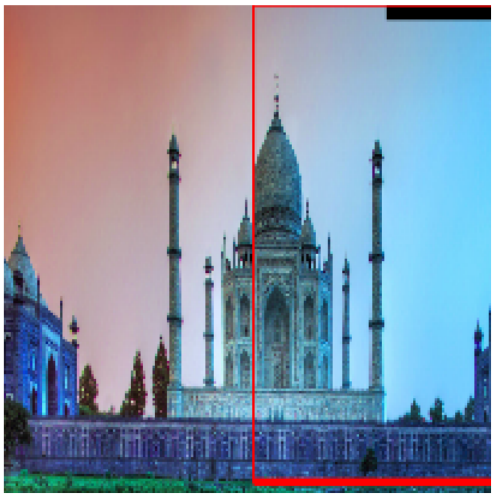
In [224]:
```
# Case 1 Hill top

# Load images
img_list = []
for i in range(1,3):
    im = cv2.imread(os.path.join(test_dir,'img1_{}.png'.format(i)))
    img_list.append(im)

M = get_transformation(img_list)
final_img = stitching(img_list,M)
final_img = remove_black(final_img)

cv2.imwrite(os.path.join(save_dir,'final_img_1.png'),final_img)

final_img = cv2.resize(final_img,(400,200))
fig = plt.figure(figsize=(16,16))
plt.imshow(final_img)
plt.axis('off')
plt.show()
```

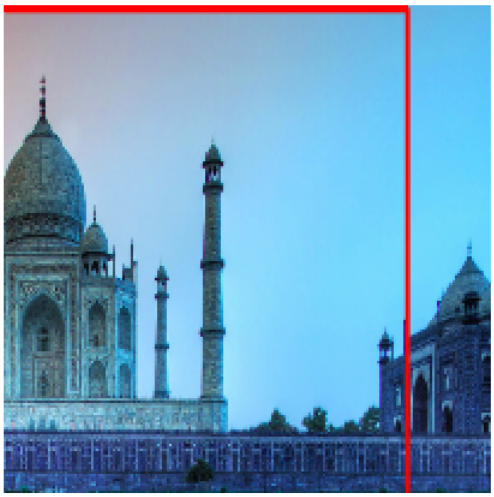


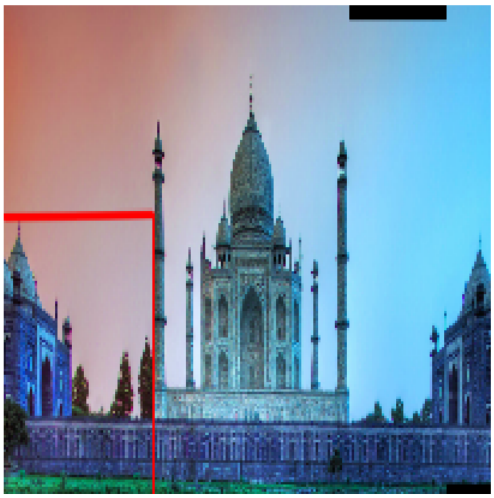
In [225]:
```
# Case 2 Taj Mahal

# Load images
img_list = []
for i in range(1,7):
    im = cv2.imread(os.path.join(test_dir,'img2_{}.png'.format(i)))
    img_list.append(im)

# 1 & 2
M = get_transformation(img_list[0:2])
final_img = stitching(img_list,M)
final_img = remove_black(final_img)

# fig = plt.figure(figsize=(16,16))
# plt.imshow(final_img)
# plt.axis('off')
# plt.show()

# 3
M = get_transformation([final_img,img_list[2]])
final_img = stitching([final_img,img_list[2]],M)
final_img = remove_black(final_img)

# fig = plt.figure(figsize=(16,16))
# plt.imshow(final_img)
# plt.axis('off')
# plt.show()
```

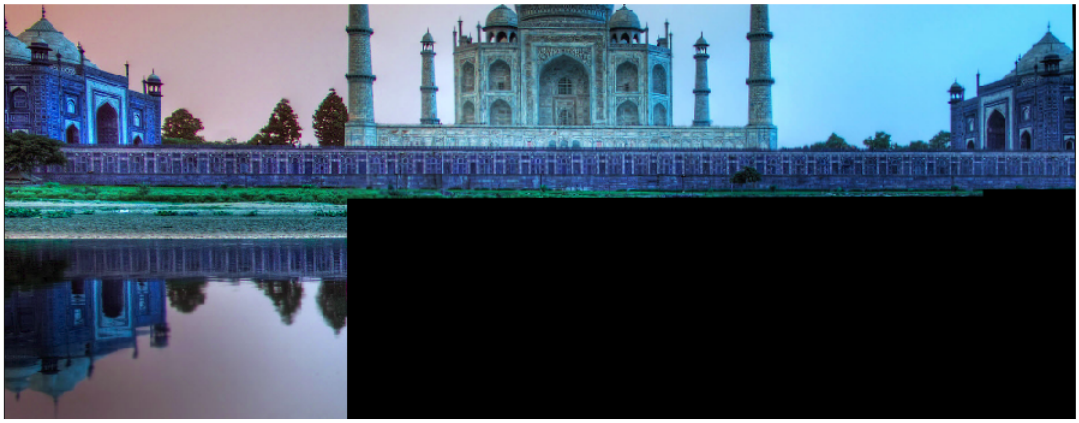
```
# 4
M = get_transformation([img_list[3],final_img])
final_img = stitching([img_list[3],final_img],M)
final_img = remove_black(final_img)

fig = plt.figure(figsize=(16,16))
plt.imshow(final_img)
plt.axis('off')
plt.show()

# 5
M = get_transformation([final_img,img_list[4]])
final_img = stitching([final_img,img_list[4]],M)
final_img = remove_black(final_img)

# fig = plt.figure(figsize=(16,16))
# plt.imshow(final_img)
# plt.axis('off')
# plt.show()


# 6
M = get_transformation([final_img,img_list[5]])
final_img = stitching([final_img,img_list[5]],M)
final_img = remove_black(final_img)

# fig = plt.figure(figsize=(16,16))
# plt.imshow(final_img)
# plt.axis('off')
# plt.show()


cv2.imwrite(os.path.join(save_dir,'final_img_2.png'),final_img)
```

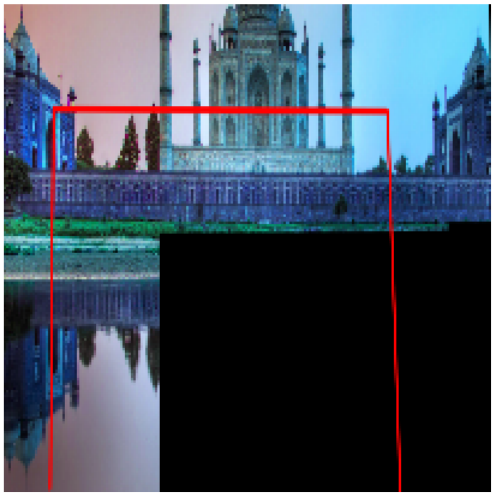


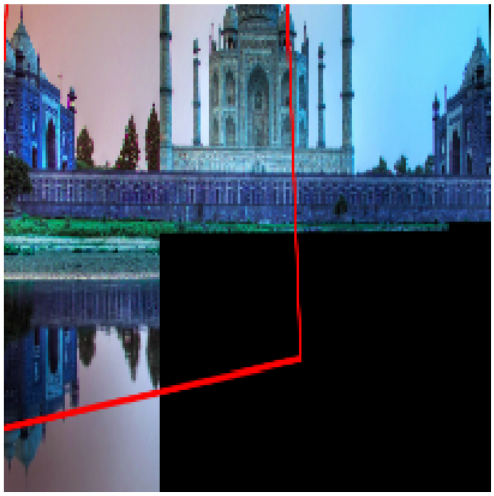












Out[225]: True

In [227]:
```
# Case 3 Cactus

# Load images
img_list = []
for i in range(1,3):
    im = cv2.imread(os.path.join(test_dir,'img3_{}.png'.format(i)))
    img_list.append(im)

M = get_transformation(img_list)
# Stitch images
cv2.imwrite(os.path.join(save_dir,'final_img_3.png'),final_img)

final_img = stitching(img_list,M)

final_img = cv2.resize(final_img,(400,200))

fig = plt.figure(figsize=(16,16))
plt.imshow(final_img)
plt.show()
```

In [228]:
```
# Case 4 Text

# Load images
img_list = []
for i in range(1,3):
    im = cv2.imread(os.path.join(test_dir,'img4_{}.jpg'.format(i)))
    img_list.append(im)

M = get_transformation(img_list)
# Stitch images
```

```
final_img = stitching(img_list,M)

cv2.imwrite(os.path.join(save_dir,'final_img_4.png'),final_img)
final_img = cv2.resize(final_img,(400,200))

fig = plt.figure(figsize=(16,16))
plt.imshow(final_img)
plt.show()
```