stereo_matching

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0.1 Assignment 3 Stereo Matching

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```
In [1]: import cv2
        import numpy as np
        import matplotlib.pyplot as plt
```

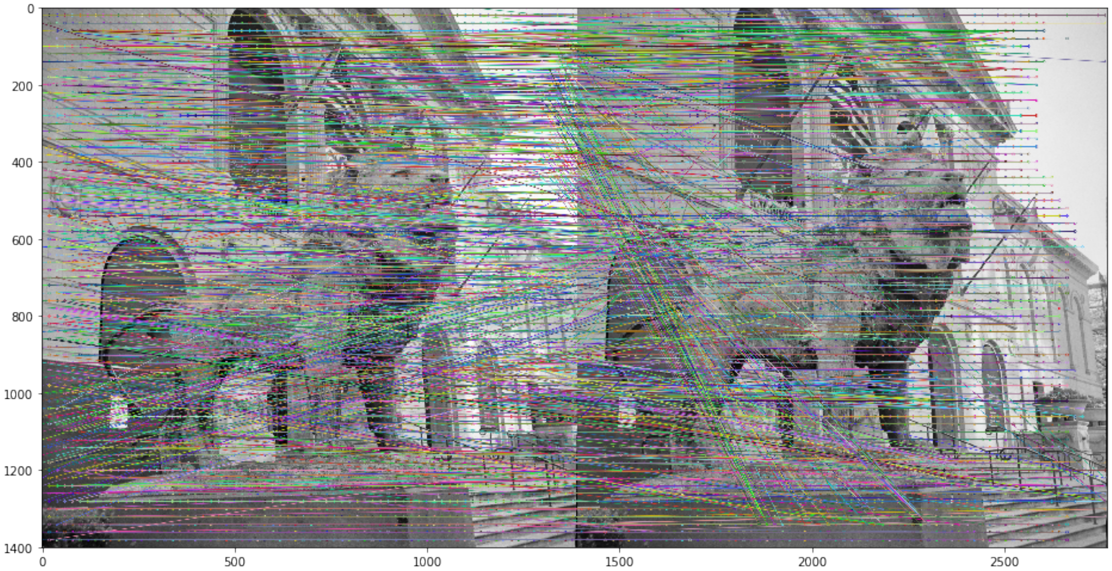
```
In [2]: img = cv2.imread('Stereo_Images/Stereo_Pair1.jpg')
        gray= cv2.cvtColor(img ,cv2.COLOR_BGR2GRAY)
        [h,w] = gray.shape

        gray1 = gray[:,0:round(w/2)]
        gray2 = gray[:,round(w/2):w]
```

```
In [3]: def dense_shift(gray1,gray2, step_size):
            sift = cv2.xfeatures2d.SIFT_create()
                # find the keypoints and descriptors with SIFT
            kp = [cv2.KeyPoint(x, y, step_size) for y in range(0, gray1.shape[0], step_size)
                                                for x in range(0, gray1.shape[1], step_size)]
            kp1,des1 = sift.compute(gray1,kp)
            kp2,des2 = sift.compute(gray2,kp)

            return kp1,des1,kp2,des2
```

```
In [4]: def dense_sift_matching(gray1,gray2):
            kp1,des1,kp2,des2 = dense_shift(gray1,gray2, 20)
            #out1 = cv2.drawKeypoints(gray2,kp2,None)
            #plt.imshow(out1),plt.show()

            # Match descriptors.
            bf = cv2.BFMatcher()
            matches = bf.match(des1,des2)

         # Sort them in the order of their distance.
            matches = sorted(matches, key = lambda x:x.distance)

         # Draw first 10 matches.
```

```
        out = cv2.drawMatches(gray1,kp1,gray2,kp2,matches ,None, flags=2)
        fig=plt.figure(figsize=(16, 16))
        plt.imshow(out),plt.show()
```

```
In [5]: dense_sift_matching(gray1,gray2)
```



0.2.1 Intensity based correlation method

0.2.2 we are only using each 10 th pixles of image1 as feature and seraching it to 20 x20 area of second image with 5x5 template matching size. It will be 15x15 search for each feature.

```
In [6]: def intensity_correlation(gray1,gray2,rectified,debug):

            [h,w] = gray1.shape
            matches = []
            for row in range(10,h-10,30):
                for col in range(10,w-10,30):

                    ## fixed the collumn
                    if (debug):
                        col = 540
                    key = [row,col]

                    template = gray1[row-1:row+2,col-1:col+2]
                    #print(template.shape)
                    if(rectified):
                        window = gray2[row-1:row+2,col-10:col+10]
                        res = cv2.matchTemplate(window,template,eval('cv2.TM_CCORR_NORMED'))
                        min_val, max_val, min_loc, max_loc = cv2.minMaxLoc(res)
                        row2 = max_loc[1] + row
                        col2 = max_loc[0] + col-9
                    else:
                        window = gray2[row-10:row+10,col-10:col+10]
                        res = cv2.matchTemplate(window,template,eval('cv2.TM_CCORR_NORMED'))
                        min_val, max_val, min_loc, max_loc = cv2.minMaxLoc(res)

                        row2 = max_loc[1] + row -9
                        col2 = max_loc[0] + col-9

                    matches.append([row,col,row2,col2])
            return matches
```

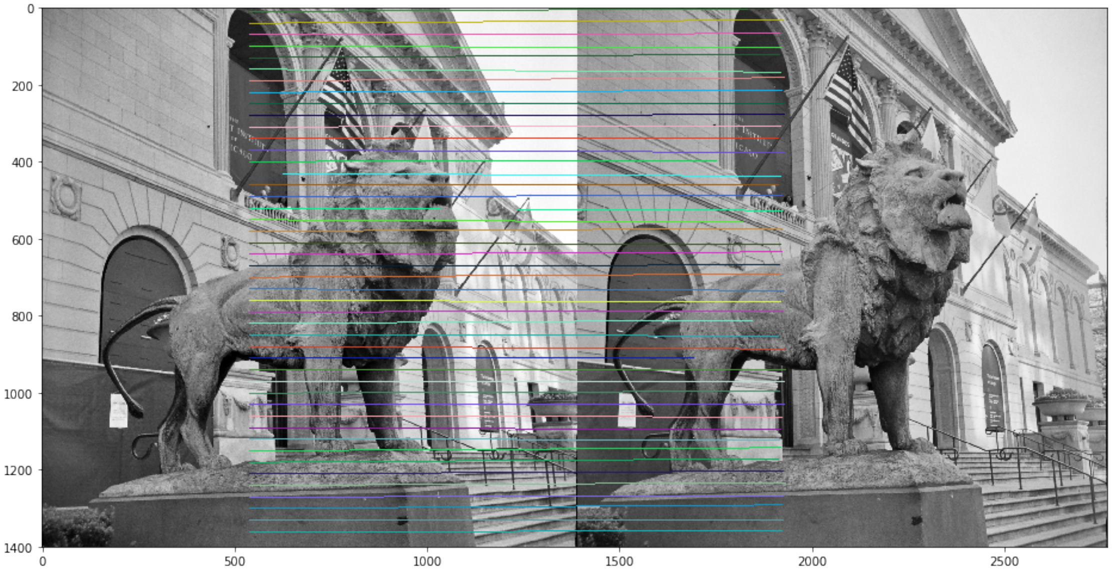
```
In [7]:     # Apply template Matching
            #res = cv.matchTemplate(img,template,method)
            #min_val, max_val, min_loc, max_loc = cv.minMaxLoc(res)
```

```
In [ ]:
```

```
In [8]: import random
        def draw_window_match(gray,window_matches):

            [h,w] = gray.shape
            gray_d = gray.copy()
            gray_d= cv2.cvtColor(gray_d ,cv2.COLOR_GRAY2BGR)
            for match in window_matches:

                cv2.line(gray_d,(int(match[1]),int(match[0])),(int(round(match[3] + w/2)),int(ma
                #print(match)
            fig=plt.figure(figsize=(16, 16))
            plt.imshow(gray_d,cmap='gray'),plt.show()
```

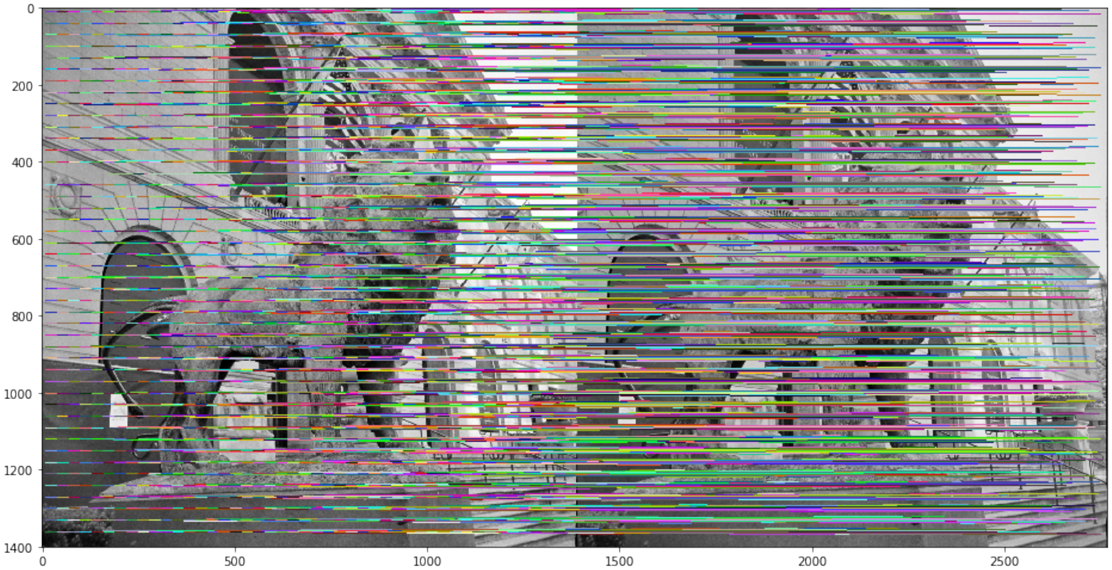
0.2.3 just to deubug and show result of matching only one clumn pixel

```
In [9]: window_matches_debug = intensity_correlation(gray1,gray2,False,True)
        draw_window_match(gray,window_matches_debug)
```



0.2.4 full feature matching of 20 by 20 grid window method

```
In [10]: window_matches = intensity_correlation(gray1,gray2,False,False)
         draw_window_match(gray,window_matches)
```



As there are no epipolar constarined window matching is very poor technique to find correspondance point and it is time consuming. In case shift looks better as it select the keyfeature points and perform the matching but its limited only for keypoint features.

0.2.5 Function to calculate fundamental matrix

```
In [11]: def point1_point2_matrix(img_point1, img_point2):

             xl1 = img_point1[0,0]
             xr1 = img_point2[0,0]
             yl1 = img_point1[0,1]
             yr1 = img_point2[0,1]

             pointX = [xr1*xl1, xr1*yl1, xr1, yr1*xl1, yr1*yl1, yr1,
                       xl1,yl1,1]
             return pointX

         def calculate_fundamental_matrix(img1_points,img2_points):
             #M = np.empty((2*img_points.shape[0], 12),dtype='int64')
             A = []
             count = 0
             for img1_point,img2_point in zip(img1_points,img2_points):
                 pointX = point1_point2_matrix(img1_point,img2_point)
                 #print(pointX,pointY)
                 ## 2x9 matr
                 #np.append(M,np.array(A_point),axis=0)
                 A.append(pointX)

             A = np.array(A)
             ### perfomr SVD
             u, s, vh = np.linalg.svd(A, full_matrices=True)
             #print(u.shape,s.shape,vh.shape)
             ## use the last value
             M = np.transpose(vh)
             M_1d = M[:,-1]
             M_1d = M_1d/M_1d[-1]
             M_2d = np.reshape(M_1d,[3,3])

             # correctness of fundamnetal matrix
             u1,s1,vh1 = np.linalg.svd(M_2d, full_matrices=True)

             s2 = np.diag(s1)

             s2[2,2] = 0

             #print(u1.shape,s2.shape,vh1.shape)

             F = np.dot(np.dot(u1,s2),vh1)
             F = F/F[2,2]

             return F
```

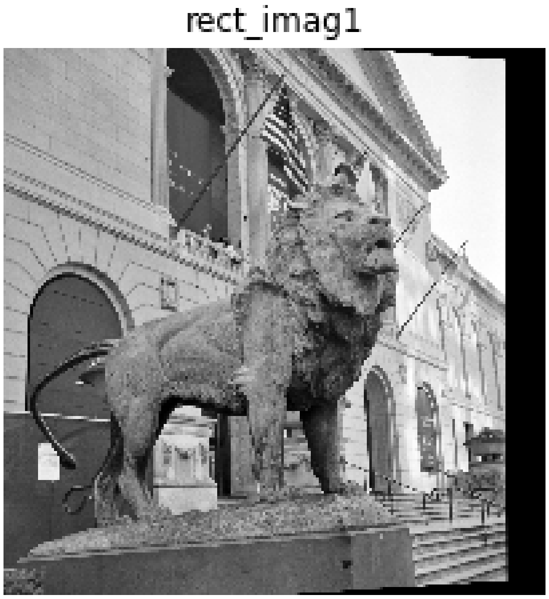
0.2.6 Image rectification

```
In [12]: def image_rectification(img1,img2):

             #img2 = cv2.cvtColor(img_2,cv2.COLOR_BGR2GRAY)

             #img1 = cv2.cvtColor(img_1,cv2.COLOR_BGR2GRAY)

             #find the shift point

             sift = cv2.xfeatures2d.SIFT_create()
             # find the keypoints and descriptors with SIFT
             kp1, des1 = sift.detectAndCompute(img1,None)
             kp2, des2 = sift.detectAndCompute(img2,None)


             ## match the points
             bf = cv2.BFMatcher()
             matches = bf.knnMatch(des1,des2, k=2)


             # select the good points
             selected_match = []
             number_of_good_point=0
             for match in matches:
                 if match[0].distance < 0.5*match[1].distance:
                     selected_match.append(match)
                     number_of_good_point = number_of_good_point+1
             matches = np.asarray(selected_match)
                 #if len(matches[:,0]) >= 4:
             ## check if number of good matched points are greater or equal to 4
             if number_of_good_point >= 9:
                 src = np.float32([ kp1[m.queryIdx].pt for m in matches[:,0] ]).reshape(-1,1,2)
                 dst = np.float32([ kp2[m.trainIdx].pt for m in matches[:,0] ]).reshape(-1,1,2)
                 ## calculate the homography

                 #F = calculate_fundamental_matrix(src,dst)
                 F, mask = cv2.findFundamentalMat(src,dst,cv2.FM_LMEDS)

                 ret,H1,H2 = cv2.stereoRectifyUncalibrated(src,dst,F,(img1.shape[1],img1.shape[0
                 ## perform the image warping
                 # warp the image1 in with homograply
                 inv_H1 = np.linalg.inv(H1)
                 rect_img1 = cv2.warpPerspective(img1,H1,(img1.shape[1],img1.shape[0]))
                 rect_img2 = cv2.warpPerspective(img2,H2,(img2.shape[1],img2.shape[0]))

                 return rect_img1,rect_img2
             else:
                print ("no proper matches found")
                return None
```

```
In [13]: rect_gray1,rect_gray2 = image_rectification(gray1,gray2)
```

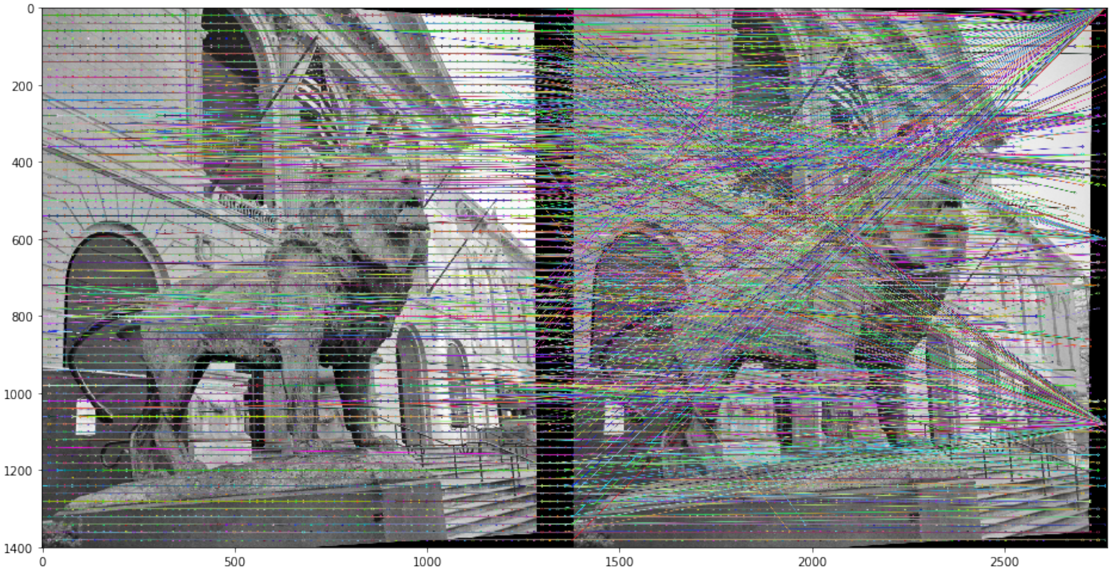
```
In [14]: #rect_gray1
```

```
In [15]: fig=plt.figure(figsize=(8, 8))
         columns = 2
         rows = 1

         fig.add_subplot(rows, columns, 1)
         plt.axis("off")
         plt.title("rect_imag1")
         plt.imshow(rect_gray1,cmap='gray'),plt.show()
         fig.add_subplot(rows, columns, 2)
         plt.axis("off")
         plt.title("rect_imag2")
         plt.imshow(rect_gray2,cmap='gray'),plt.show()
```



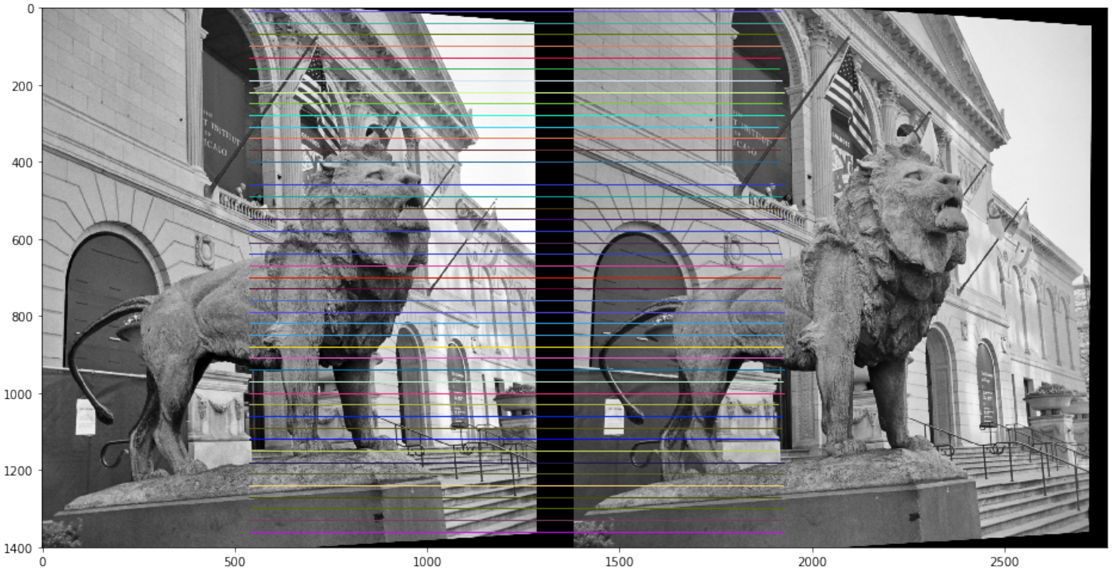
```
Out[15]: (<matplotlib.image.AxesImage at 0x7f5ff1bc8828>, None)
```

```
In [16]: dense_sift_matching(rect_gray1,rect_gray2)
```

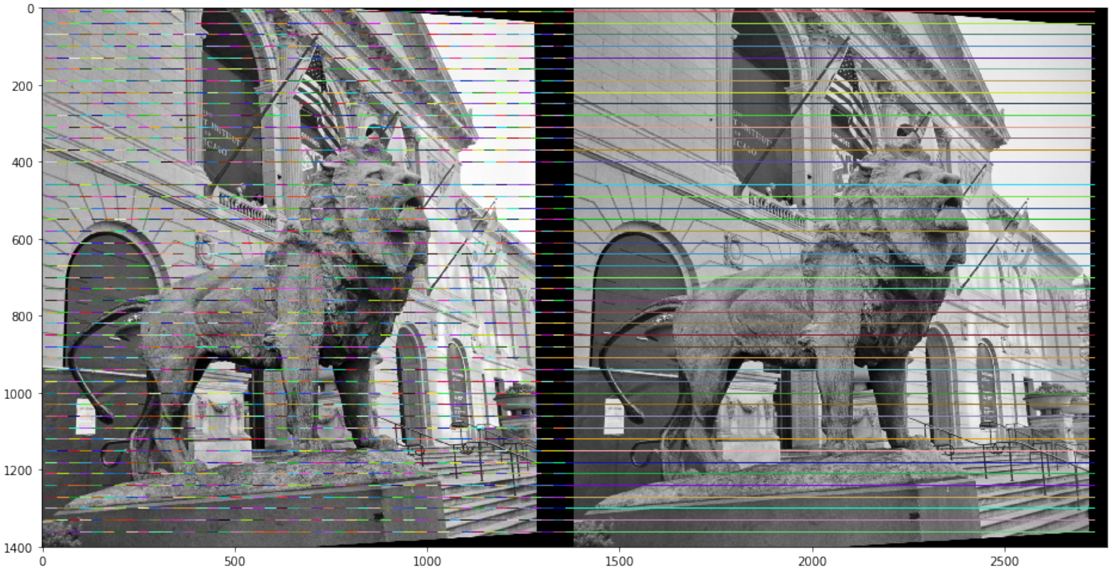


now wee need to search one column (line) to find the correspondance point as our images is rectified

```
In [17]: window_matches = intensity_correlation(rect_gray1,rect_gray2,True,True)

         #print(window_matches)

         rect_gray = np.concatenate((rect_gray1,rect_gray2),axis=1)
         draw_window_match(rect_gray,window_matches)
```



```
In [18]: window_matches = intensity_correlation(rect_gray1,rect_gray2,True,False)

         #print(window_matches)

         rect_gray = np.concatenate((rect_gray1,rect_gray2),axis=1)
         draw_window_match(rect_gray,window_matches)
```



```
In [19]: ## create_row_feature_list it will be only work for rectified images

In [20]: def create_row_feature_list(img1,img2):

             #img2 = cv2.cvtColor(img_2,cv2.COLOR_BGR2GRAY)

             #img1 = cv2.cvtColor(img_1,cv2.COLOR_BGR2GRAY)

             #find the shift point

             sift = cv2.xfeatures2d.SIFT_create()
             # find the keypoints and descriptors with SIFT
             kp1, des1 = sift.detectAndCompute(img1,None)
             kp2, des2 = sift.detectAndCompute(img2,None)


             [h,w] = img1.shape

             A1 = {}
             A2 = {}
             for row in range(0,h):

                 temp_list1 = []
                 temp_list2 = []
                 for keypoint1 in kp1:
                 ## if keypoint in row
                     if (row == round(keypoint1.pt[1])):
                         temp_list1.append(keypoint1.pt[0])
                 A1[str(row)]= temp_list1

                 for keypoint2 in kp2:
                 ## if keypoint in row

                     if (row == round(keypoint2.pt[1])):
                         temp_list2.append(keypoint2.pt[0])

                 A2[str(row)]=temp_list2
             return A1,A2
```

```
In [21]: A1,A2 = create_row_feature_list(rect_gray1,rect_gray2)
```

```
In [22]: A1['3']
```

```
Out[22]: [553.8052368164062, 734.1897583007812, 804.4258422851562]
```

```
In [ ]:
```

0.2.7 DTW matching

```
In [23]: def DTW (y,x):
             D = np.zeros((len(y), len(x)))
             for i in range(len(y)):
                 for j in range(len(x)):
                     D[i,j] = (x[j]-y[i])**2


             accumulated_cost = np.zeros((len(y), len(x)))
             accumulated_cost[0,0] = D[0,0]
             for i in range(1, len(y)):
                 accumulated_cost[i,0] = D[i, 0] + accumulated_cost[i-1, 0]
             for i in range(1, len(x)):
                 accumulated_cost[0,i] = D[0,i] + accumulated_cost[0, i-1]
             for i in range(1, len(y)):
                 for j in range(1, len(x)):
                     accumulated_cost[i, j] = min(accumulated_cost[i-1, j-1], accumulated_cost[i

             def path_cost(x, y, accumulated_cost, distances):
                 path = [[len(x)-1, len(y)-1]]
                 cost = 0
                 i = len(y)-1
                 j = len(x)-1
                 while i>0 and j>0:
                     if i==0:
                         j = j - 1
                     elif j==0:
```

```
                i = i - 1
            else:
                if accumulated_cost[i-1, j] == min(accumulated_cost[i-1, j-1], accumula
                    i = i - 1
                elif accumulated_cost[i, j-1] == min(accumulated_cost[i-1, j-1], accumu
                    j = j-1
                else:
                    i = i - 1
                    j= j- 1
            path.append([j, i])
        path.append([0,0])
        for [y, x] in path:
            cost = cost +distances[x, y]
        return path, cost
    path, cost = path_cost(x, y, accumulated_cost, D)

    return path,cost
```

```
In [24]: ## DTW

         for key in range(0,10):

             #chek if both row have features in both images
             if (A1[str(key)] != []) & (A2[str(key)] != []):

                 row_feature1 = A1[str(key)]
                 row_feature2 = A2[str(key)]

                 print("row number" , key)
                 print("number_of_feature" ,len(row_feature1),len(row_feature1))




                 #print (path,cost)


                 paths,cost = DTW(row_feature2,row_feature1)
                 print("map of columns with img1 and img2 ", paths,"cost",cost)
```

```
row number 3
number_of_feature 3 3
map of columns with img1 and img2  [[2, 5], [1, 5], [0, 4], [0, 0]] cost 24387.719198711216
row number 4
number_of_feature 4 4
map of columns with img1 and img2  [[3, 3], [2, 3], [1, 2], [1, 1], [0, 0], [0, 0]] cost 98605.1
row number 5
number_of_feature 5 5
```

```
map of columns with img1 and img2  [[4, 3], [3, 2], [3, 1], [2, 0], [0, 0]] cost 75597.345527077
row number 6
number_of_feature 5 5
map of columns with img1 and img2  [[4, 8], [3, 7], [2, 6], [2, 5], [2, 4], [2, 3], [1, 2], [1,
row number 7
number_of_feature 10 10
map of columns with img1 and img2  [[9, 3], [8, 3], [7, 3], [6, 3], [5, 3], [4, 3], [3, 2], [2,
row number 8
number_of_feature 4 4
map of columns with img1 and img2  [[3, 5], [2, 4], [2, 3], [2, 2], [1, 1], [0, 0], [0, 0]] cost
row number 9
number_of_feature 3 3
map of columns with img1 and img2  [[2, 2], [1, 1], [0, 0], [0, 0]] cost 175061.86378520913
```

```
In [25]: ## above show the matching of point
```