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Q(1)

```
In [80]: import numpy as np
from scipy.optimize import minimize
from scipy import linalg
import matplotlib.pyplot as plt

#np.random.seed(0)
N = 100
half_n = N//2
r = 10
s = r/16
t = np.random.uniform (0,2*np.pi,half_n)
n = s*np.random.randn(half_n)
x,y = (r + n)*np.cos( t ),( r + n)*np.sin( t )
X_circ = np.hstack((x.reshape(half_n,1),y.reshape(half_n,1))) #List of coordinates of points
figure, axes = plt.subplots(figsize=(10,10))
#RANSAC Algorithm
N = 80; #number of repetitive fittings
Inlier_ratio=0.9 # Inlier ratio
marginal_dis = 1; #distance from circle that points are considered as inliers
critic_inlier_count = 40
for i in range(0,N,1):
    #choosing 3 random points to uniquely define a circle
    ind_1,ind_2,ind_3 =np.random.randint(50),np.random.randint(50),np.random.randint(50)
    coord_1,coord_2,coord_3 = X_circ[ind_1],X_circ[ind_2],X_circ[ind_3]
    x1,y1,x2,y2,x3,y3=coord_1[0],coord_1[1],coord_2[0],coord_2[1],coord_3[0],coord_3[1]
    #calculating centre and radius of the circle
    c = (x1-x2)**2 + (y1-y2)**2
    a = (x2-x3)**2 + (y2-y3)**2
    b = (x3-x1)**2 + (y3-y1)**2
    s = 2*(a*b + b*c + c*a) - (a*a + b*b + c*c)
    cent_x = (a*(b+c-a)*x1 + b*(c+a-b)*x2 + c*(a+b-c)*x3) / s
    cent_y = (a*(b+c-a)*y1 + b*(c+a-b)*y2 + c*(a+b-c)*y3) / s
    ar = a**0.5
    br = b**0.5
    cr = c**0.5
    radi = ar*br*cr / ((ar+br+cr)*(-ar+br+cr)*(ar-br+cr)*(ar+br-cr))**0.5

    inlier_count=0;
    #distance to the points
    for j in range(0,50):
        dis=((X_circ[j][0]-cent_x)**2 +(X_circ[j][1]-cent_y)**2)**0.5
        Is_inlier=abs(dis-radi)<=marginal_dis
        if(Is_inlier):
            inlier_count+=1

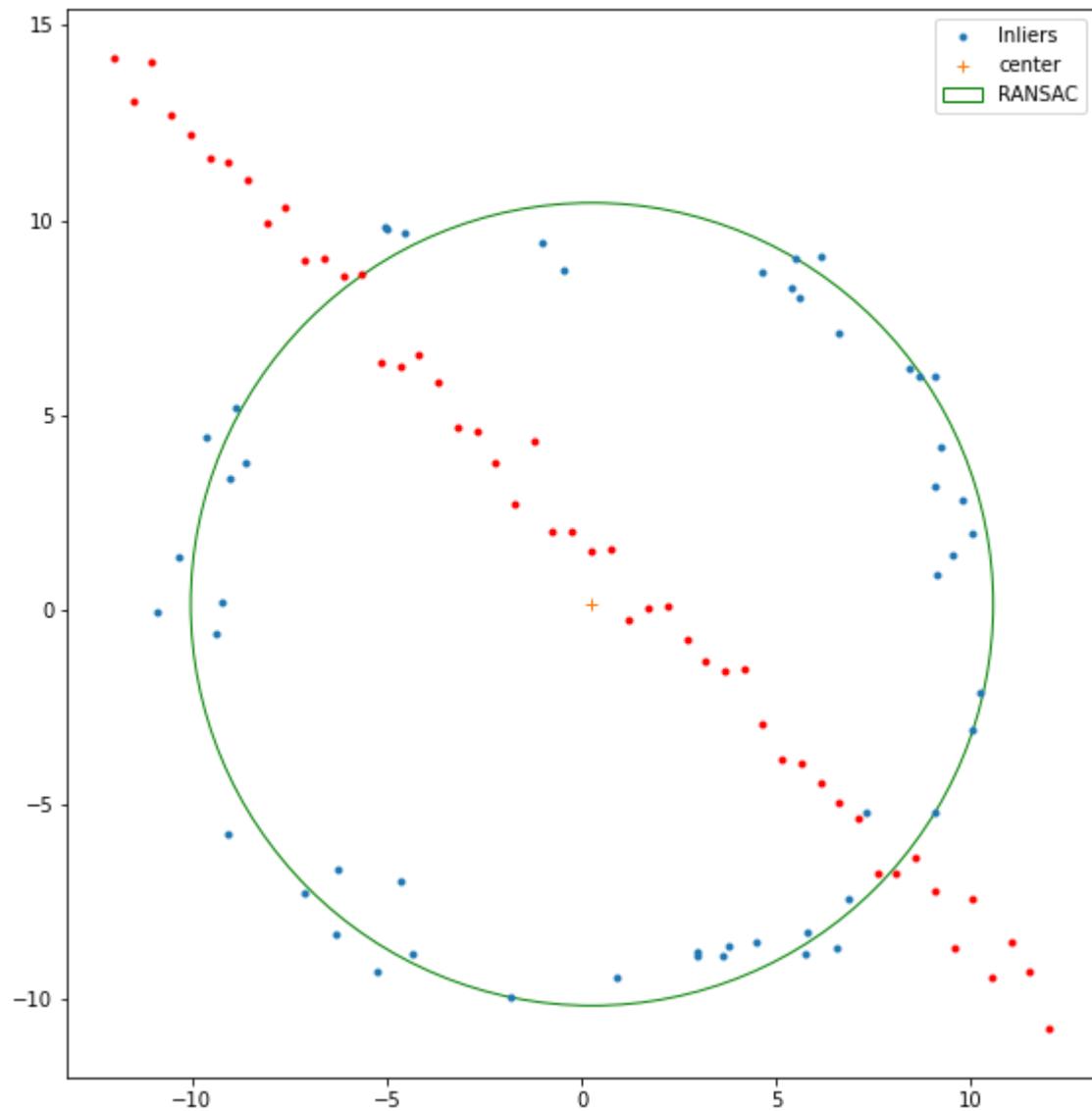
    if(critic_inlier_count<=inlier_count):
        axes.plot(x,y,".",label="Inliers")
        axes.plot(cent_x,cent_y,'+',label='center')
        draw_circle = plt.Circle((cent_x,cent_y), radi, fill=False,color='g',label='RAN')
        axes.set_aspect(1)
        axes.add_artist(draw_circle)
```

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plt.legend()
break

#plotting rest of points
m,b = -1,2
s=r/16
x_line = np.linspace(-12,12,half_n)
y_line = m*x_line+b + s*np.random.randn(half_n)
X_line = np.hstack((x.reshape(half_n,1), y.reshape(half_n,1)))
X = np.vstack((X_circ,X_line))
plt.plot(x_line,y_line,".",color='r')
plt.show()

```



Q(2)

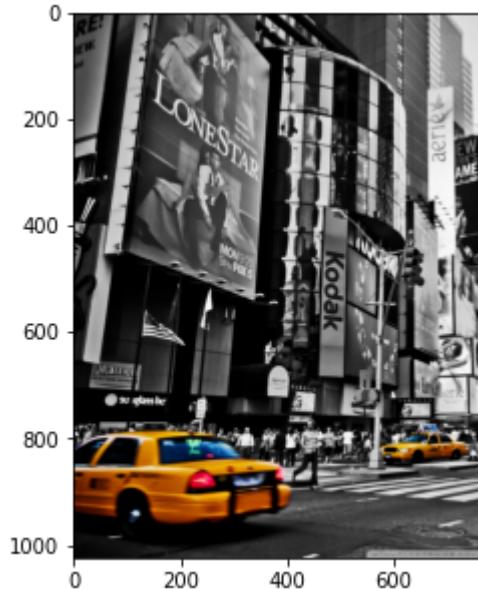
```

In [24]: import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline

im1 = cv.imread(r'back_image.jpg',cv.IMREAD_COLOR)
assert im1 is not None

```

```
im2 = cv.imread(r'front_image1.jpg',cv.IMREAD_COLOR)
assert im2 is not None
img1_plt = cv.cvtColor(im1, cv.COLOR_BGR2RGB)
fig,ax = plt.subplots(figsize=(12,5))
ax.imshow(img1_plt)
plt.show()
```



In [19]: *# fuction use to identify points using mouse clicks*

```
import cv2 as cv

def click_event(event, x, y, flags, params):
    if event == cv.EVENT_LBUTTONDOWN:
        print(x, ' ', y)
        cv.imshow('image', img)

img = cv.imread(r'back_image.jpg', 1)
cv.imshow('image', img)
cv.setMouseCallback('image', click_event)
cv.waitKey(0)
cv.destroyAllWindows()
```

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In [23]:

```
import numpy as np
import cv2 as cv
import matplotlib.pyplot as plt
%matplotlib inline

backimg = cv2.imread(r'back_image.jpg')
frontimg = cv2.imread(r'front_image1.jpg')
assert backimg is not None
assert frontimg is not None

#four corners of the back image to be replaced-----
pts_backimg = np.array([[474,363], [516,371], [508,685], [462,685]])

#four corners of our front image
pts_frontimg = np.array([[0, 0], [frontimg.shape[1] - 1, 0], [frontimg.shape[1] - 1, f
```

```
#Calculate homography matrix
homographyMatrix, status = cv.findHomography(pts_frontimg, pts_backimg)

#warp frontimg to backimg
result1 = cv.warpPerspective(frontimg, homographyMatrix, (backimg.shape[1], backimg.shape[0]))

#removing the rest of area in back image
cv.fillConvexPoly(backimg, pts_backimg, 0, 16)

#Add warped image to the backimage
result = backimg + result1

#display image
result = cv.cvtColor(result, cv.COLOR_BGR2RGB)
plt.imshow(result)
plt.show()
```



Q(3)

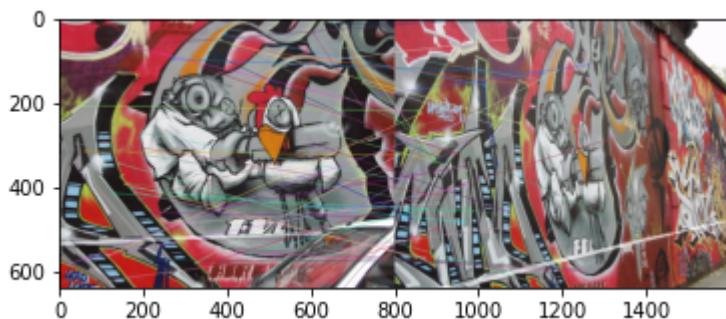
a)

In [92]:

```
import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline

img1 = cv.imread('img1.ppm')
img2 = cv.imread('img5.ppm')
assert img1 is not None
assert img2 is not None

img1 = cv.cvtColor(img1, cv.COLOR_BGR2RGB)
img2 = cv.cvtColor(img2, cv.COLOR_BGR2RGB)
sift = cv.SIFT_create()
keypoints_1, descriptors_1 = sift.detectAndCompute(img1, None)
keypoints_2, descriptors_2 = sift.detectAndCompute(img2, None)
bf = cv.BFMatcher(cv.NORM_L1, crossCheck=True)
matches = bf.match(descriptors_1, descriptors_2)
matches = sorted(matches, key = lambda x:x.distance)
img3 = cv.drawMatches(img1, keypoints_1, img2, keypoints_2, matches[:50], img2, flags=2)
plt.imshow(img3)
plt.show()
```



b)

In [25]:

```

import cv2
import numpy as np
import getopt
import sys
import random

#
# Read in an image file, errors out if we can't find the file
#
def readImage(filename):
    img = cv2.imread(filename, 0)
    if img is None:
        print('Invalid image:' + filename)
        return None
    else:
        print('Image successfully read...')
        return img

# This draws matches and optionally a set of inliers in a different color
# Note: I lifted this drawing portion from stackoverflow and adjusted it to my needs to
# include the drawMatches function
def drawMatches(img1, kp1, img2, kp2, matches, inliers = None):
    # Create a new output image that concatenates the two images together
    rows1 = img1.shape[0]
    cols1 = img1.shape[1]
    rows2 = img2.shape[0]
    cols2 = img2.shape[1]

    out = np.zeros((max([rows1,rows2]),cols1+cols2,3), dtype='uint8')

    # Place the first image to the left
    out[:rows1,:cols1,:] = np.dstack([img1, img1, img1])

    # Place the next image to the right of it
    out[:rows2,cols1:cols1+cols2,:] = np.dstack([img2, img2, img2])

    # For each pair of points we have between both images
    # draw circles, then connect a line between them
    for mat in matches:

        # Get the matching keypoints for each of the images
        img1_idx = mat.queryIdx
        img2_idx = mat.trainIdx

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# x - columns, y - rows
(x1,y1) = kp1[img1_idx].pt
(x2,y2) = kp2[img2_idx].pt

inlier = False

if inliers is not None:
    for i in inliers:
        if i.item(0) == x1 and i.item(1) == y1 and i.item(2) == x2 and i.item(3) == y2:
            inlier = True

# Draw a small circle at both co-ordinates
cv2.circle(out, (int(x1),int(y1)), 4, (255, 0, 0), 1)
cv2.circle(out, (int(x2)+cols1,int(y2)), 4, (255, 0, 0), 1)

# Draw a Line in between the two points, draw inliers if we have them
if inliers is not None and inlier:
    cv2.line(out, (int(x1),int(y1)), (int(x2)+cols1,int(y2)), (0, 255, 0), 1)
elif inliers is not None:
    cv2.line(out, (int(x1),int(y1)), (int(x2)+cols1,int(y2)), (0, 0, 255), 1)

if inliers is None:
    cv2.line(out, (int(x1),int(y1)), (int(x2)+cols1,int(y2)), (255, 0, 0), 1)

return out

#
# Runs sift algorithm to find features
#
def findFeatures(img):
    print("Finding Features...")
    sift = cv2.SIFT()
    keypoints, descriptors = sift.detectAndCompute(img, None)

    img = cv2.drawKeypoints(img, keypoints)
    cv2.imwrite('sift_keypoints.png', img)

    return keypoints, descriptors

#
# Matches features given a list of keypoints, descriptors, and images
#
def matchFeatures(kp1, kp2, desc1, desc2, img1, img2):
    print("Matching Features...")
    matcher = cv2.BFMatcher(cv2.NORM_L2, True)
    matches = matcher.match(desc1, desc2)
    matchImg = drawMatches(img1,kp1,img2,kp2,matches)
    cv2.imwrite('Matches.png', matchImg)
    return matches

#
# Computes a homography from 4-correspondences
#
def calculateHomography(correspondences):
    #Loop through correspondences and create assemble matrix
    aList = []
    for corr in correspondences:
        p1 = np.matrix([corr.item(0), corr.item(1), 1])
        p2 = np.matrix([corr.item(2), corr.item(3), 1])

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a2 = [0, 0, 0, -p2.item(2) * p1.item(0), -p2.item(2) * p1.item(1), -p2.item(2)
      p2.item(1) * p1.item(0), p2.item(1) * p1.item(1), p2.item(1) * p1.item(2)
      p2.item(0) * p1.item(0), p2.item(0) * p1.item(1), -p2.item(2) * p1.item(2)
aList.append(a1)
aList.append(a2)

matrixA = np.matrix(aList)

#svd composition
u, s, v = np.linalg.svd(matrixA)

#reshape the min singular value into a 3 by 3 matrix
h = np.reshape(v[8], (3, 3))

#normalize and now we have h
h = (1/h.item(8)) * h
return h

#
#Calculate the geometric distance between estimated points and original points
#
def geometricDistance(correspondence, h):

    p1 = np.transpose(np.matrix([correspondence[0].item(0), correspondence[0].item(1),
                                estimatep2 = np.dot(h, p1)
                                estimatep2 = (1/estimatep2.item(2))*estimatep2

    p2 = np.transpose(np.matrix([correspondence[0].item(2), correspondence[0].item(3),
                                error = p2 - estimatep2
    return np.linalg.norm(error)

#
#Runs through ransac algorithm, creating homographies from random correspondences
#
def ransac(corr, thresh):
    maxInliers = []
    finalH = None
    for i in range(1000):
        #find 4 random points to calculate a homography
        corr1 = corr[random.randrange(0, len(corr))]
        corr2 = corr[random.randrange(0, len(corr))]
        randomFour = np.vstack((corr1, corr2))
        corr3 = corr[random.randrange(0, len(corr))]
        randomFour = np.vstack((randomFour, corr3))
        corr4 = corr[random.randrange(0, len(corr))]
        randomFour = np.vstack((randomFour, corr4))

        #call the homography function on those points
        h = calculateHomography(randomFour)
        inliers = []

        for i in range(len(corr)):
            d = geometricDistance(corr[i], h)
            if d < 5:
                inliers.append(corr[i])

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```

        if len(inliers) > len(maxInliers):
            maxInliers = inliers
            finalH = h
        print "Corr size: ", len(corr), " NumInliers: ", len(inliers), "Max inliers: "
        if len(maxInliers) > (len(corr)*thresh):
            break
    return finalH, maxInliers

#
# Main parses argument list and runs the functions
#
def main():
    args, img_name = getopt.getopt(sys.argv[1:], '', ['threshold='])
    args = dict(args)

    estimation_thresh = args.get('--threshold')
    print "Estimation Threshold: ", estimation_thresh
    if estimation_thresh is None:
        estimation_thresh = 0.60

    img1name = str(img_name[0])
    img2name = str(img_name[1])
    print("Image 1 Name: " + img1name)
    print("Image 2 Name: " + img2name)

    #query image
    img1 = readImage(img_name[0])
    #train image
    img2 = readImage(img_name[1])

    #find features and keypoints
    correspondenceList = []
    if img1 is not None and img2 is not None:
        kp1, desc1 = findFeatures(img1)
        kp2, desc2 = findFeatures(img2)
        keypoints = [kp1,kp2]
        matches = matchFeatures(kp1, kp2, desc1, desc2, img1, img2)
        for match in matches:
            (x1, y1) = keypoints[0][match.queryIdx].pt
            (x2, y2) = keypoints[1][match.trainIdx].pt
            correspondenceList.append([x1, y1, x2, y2])

    corrs = np.matrix(correspondenceList)

    #run ransac algorithm
    finalH, inliers = ransac(corrs, estimation_thresh)
    print("Final homography: ", finalH)

    matchImg = drawMatches(img1,kp1,img2,kp2,matches,inliers)
    cv2.imwrite('InlierMatches.png', matchImg)

    f = open('homography.txt', 'w')
    f.write("Final homography: \n" + str(finalH)+"\n")
    f.write("Final inliers count: " + str(len(inliers)))
    f.close()

if __name__ == "__main__":

```

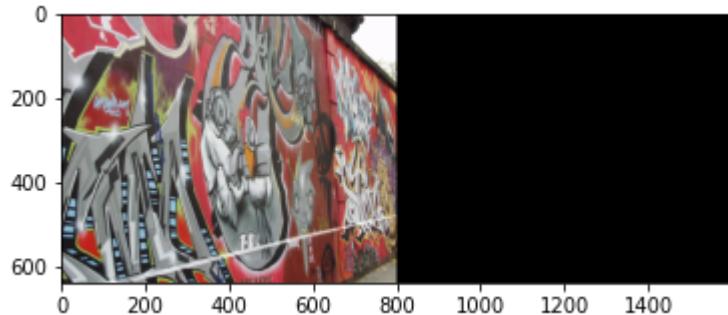
```
main()
print("Given Homography")
H_given = np.array([[6.2544644e-01, 5.7759174e-02, 2.2201217e+02], [
    2.2240536e-01, 1.1652147e+00, -2.5605611e+01],
    [4.9212545e-04, -3.6542424e-05, 1.0000000e+00]])
H_given

Input In [25]
print "Corr size: ", len(corr), " NumInliers: ", len(inliers), "Max inliers: ", len(maxInliers)
^
SyntaxError: Missing parentheses in call to 'print'. Did you mean print(...)?
```

c)

```
In [104...]: H = np.array([[6.2544644e-01, 5.7759174e-02, 2.2201217e+02], [
    2.2240536e-01, 1.1652147e+00, -2.5605611e+01],
    [4.9212545e-04, -3.6542424e-05, 1.0000000e+00]])

dst = cv.warpPerspective(img1,H,((img1.shape[1] + img2.shape[1]), img2.shape[0])) #wrc
dst[0:img2.shape[0], 0:img2.shape[1]] = img2 #stitched image
cv.imwrite('output.jpg',dst)
dst = cv.cvtColor(dst, cv.COLOR_BGR2RGB)
plt.imshow(dst)
plt.show()
```



In []: