EN2550 - Assignment 2

Fitting and Alignment

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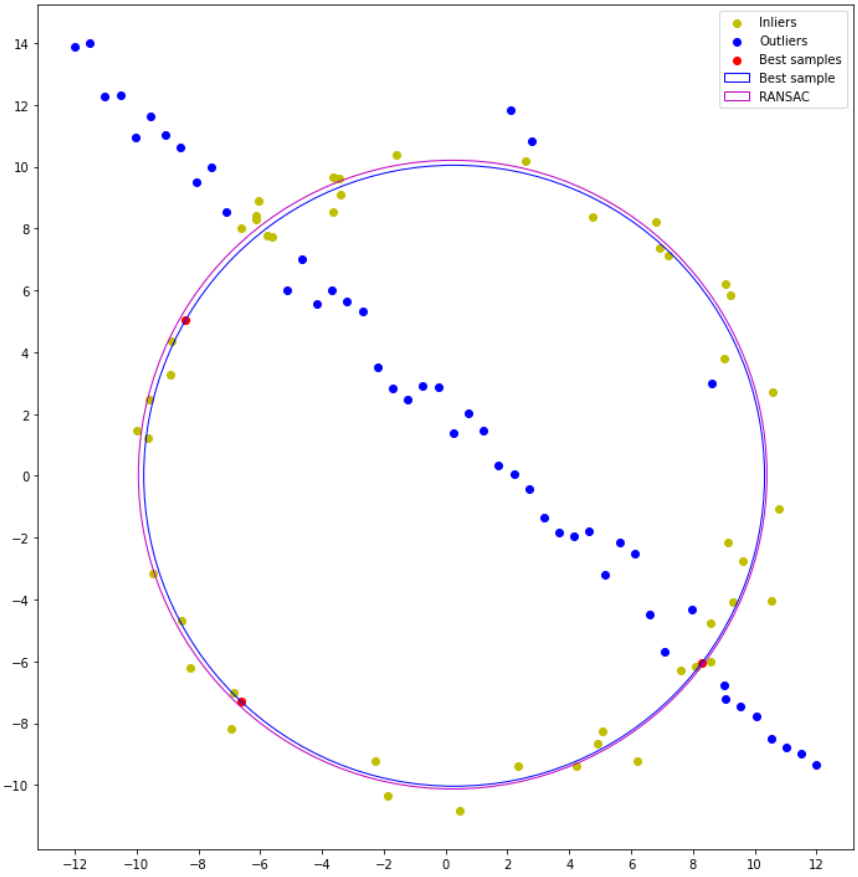
Github Repo:https://github.com/vidurawarna/EN2550_CV/tree/main/Assignments/Assignment%202

Question 1

(a) Parameter selection for RANSAC algorithm

- The initial number of points: $s = 3$
- Distance threshold: $t = \frac{10}{16} \times 1.96 = 1.225$
  (Since the noise for radius is gaussian, 95% probability capturing is considered)
- Consensus set size: $d = 50$
  (Half of the points belong to the circle)
- The probability that at least one sample is free from outliers: $p = 0.97$ (Our sample has 3 points out of 100. Therefore, $p = 0.97$)
- outlier ratio: $e = 0.5$ (50% of the total number of points)
- The number of samples: $N = \frac{\log(1-p)}{\log(1-(1-e)^s)} = \frac{\log(1-0.97)}{\log(1-(1-0.5)^3)} = 26$

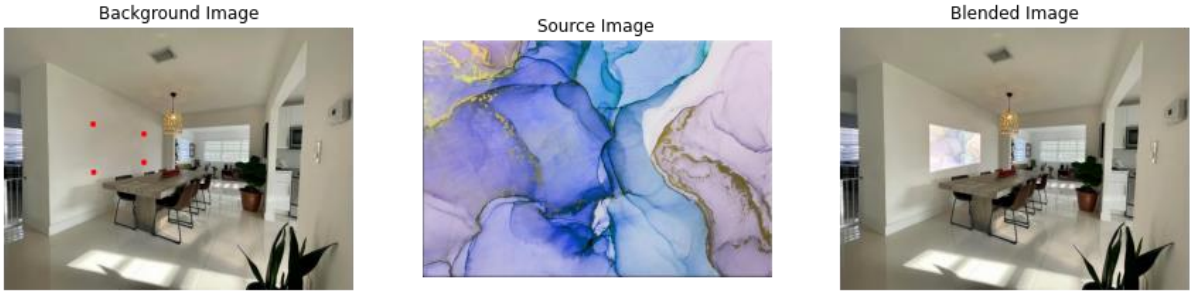
(b) RANSAC algorithm was able to detect the circle by considering only inlier points to that circle and ignore the outlier points completely. Therefore the algorithm gives the result we expected.



```
def circ_RANSAC(X,N):
    e = 0.5     # outlier ratio
    s = 3       # Number of point s need to create the estimate model
    p = 0.97    # Probability to choose number of iteration cycles
    thresh = 1.225  # Threshold distance to determine inliers and outliers
    d = 50      # expected number of inliers
    iter_rounds = int(np.log(1-p)/np.log(1-(1-e)**s))
    best_samples,best_inliers,best_outliers,best_errors,best_inlier_counts = [],[],[],[],[]
    for i in range(iter_rounds):
        [x,y,z] = random.choices(X,k=3)
        circ_x, circ_y, radius = circle(x,y,z)
        inliers,outliers = [],[]
        if not (circ_x == False and circ_y == False and radius == False):
            a, b = radius - thresh, radius + thresh
            for point in X:
                point=list(point)
                if inRange(point,circ_x,circ_y,radius - thresh,radius + thresh):
                    inliers.append(point)
                else:
                    outliers.append(point)
            if len(inliers) >= d:
                error = calError(inliers,circ_x,circ_y,radius)
                best_errors.append(error), best_samples.append([x,y,z]),
best_outliers.append(outliers)
                best_inliers.append(inliers),
best_inlier_counts.append(len(inliers))
    if len(best_inlier_counts)==0:
        circ_RANSAC(X,N)
    else:
        best = max(best_inlier_counts)
        best_inlier_counts_np = np.array(best_inlier_counts,dtype=int)
        count = np.count_nonzero(best_inlier_counts_np == best)
        if count > 1:
            indexes = np.where(best_inlier_counts_np==best)[0]
            min_i = [indexes[0],best_errors[indexes[0]]]
            for j in range(len(best_errors)):
                if (j in indexes) and (best_errors[j]<min_i[1]):
                    min_i = [j,best_errors[j]]
            k = min_i[0]
        else:
            k = best_inlier_counts.index(best)
        best_dots,inlier_dots,outlier_dots  =
np.array(best_samples[k]),np.array(best_inliers[k]),np.array(best_outliers[k])
        a,b,c = circle(best_samples[k][0],best_samples[k][1],best_samples[k][2])
        e,f,g = bestfitCircle(inlier_dots)
```

Question 2

1. Testing a wall design before putting the design physically.



2. Advertise a softdrink brand on a truck box.

3. A billboard display for a Marvel super hero movie.

Question 3

(a) The similarity features between two images are found using the SIFT feature mapping function in opencv.

(b)

- Following functions are mainly used to calculate the homography between img1.ppm and img5.ppm. The match points are generated using SIFT feature matching. Then those points are further filtered by considering geometric distance between points.
- Rather than calculating the homography ($H_{1,5}$) for img1.ppm and img5.ppm directly, ($H_{1,2}$), ($H_{2,3}$), ($H_{3,4}$), ($H_{4,5}$) homographies are calculated. Then using matrix properties, $H_{1,5}$ is obtained by ($H_{1,5}$) = ($H_{4,5}$) ($H_{3,4}$) ($H_{2,3}$) ($H_{1,2}$)
- Here ($H_{i,j}$) means homgraphy between i^{th} image and j^{th} image.

```
def solve_H(points,des_points):
# This function solves a homography using given four data points
    A=[]
    for i in range(len(points)):
        A1 = np.concatenate((np.zeros(3),-
points[i],des_points[i][1]*points[i]),axis=None)
        A2 = np.concatenate((-
points[i],np.zeros(3),des_points[i][0]*points[i]),axis=None)
        A.append(A2)
        A.append(A1)
    A = np.array(A)
    W,V = np.linalg.eig(A.T @ A)
    # Take the vector corresponds to the minimum eigen value of A.T @ A
    # Sloution H is that vector
    H = np.reshape(np.array(V[:,np.argmin(W)]),(3,3))
    return H/H[2][2]
```

```python
def H_Ransac(points):
# This function is a RANSAC algorithm for homography calculation
    (ptsLeft,ptsRight) = points
    N = 200
    inlier_counts=[]
    H_set=[]
    for _ in range(N):
        left_4 = []
        right_4 = []
        inliers=[]
        #pick random 4 points to calculate Homography
        for i in range(4):
            j = np.random.randint(0,len(ptsLeft))
            left_4.append(ptsLeft[j])
            right_4.append(ptsRight[j])
        # Find a temporary homography
        H = solve_H(left_4,right_4)
        ssd_sum = 0
        # Filter out the inlier points according to the homography
        for j in range(len(ptsLeft)):
            p = ptsLeft[j]
            p_new = (H @ np.reshape(p,(3,1)))
            p_new = p_new/p_new[2:]
            ssd= np.sqrt(np.sum(np.square(np.reshape(p_new,(1,3))-ptsRight[j])))
            if ssd<1:
                inliers.append(p)
        inlier_counts.append(len(inliers))
        H_set.append(H)
    # select the homography with most inliers
    s = H_set[inlier_counts.index(max(inlier_counts))]
    return s/s[2][2]
```

Homography which is calculated using written RANSAC code:

$$\begin{matrix} 6.25170214 \times 10^{-1} & 6.30718258 \times 10^{-2} & 2.20377906 \times 10^{2} \\ 2.19019399 \times 10^{-1} & 1.16637164 \times 10^{0} & -2.45215250 \times 10^{1} \\ 4.88113336 \times 10^{-4} & -3.34116504 \times 10^{-5} & 1 \times 10^{0} \end{matrix}$$

Given Homography:

$$\begin{matrix} 6.2544644 \times 10^{-1} & 5.7759174 \times 10^{-2} & 2.2201217 \times 10^{2} \\ 2.2240536 \times 10^{-1} & 1.1652147 \times 10^{0} & -2.5605611 \times 10^{1} \\ 4.9212545 \times 10^{-4} & -3.6542424 \times 10^{-5} & 1 \times 10^{0} \end{matrix}$$

- There are some slight differences of the values in the matrices. But they are not significant. Therefore, it can be concluded that this method can be used to calculate the homography between two images successfully.

(c) Image 1 is stitched to Image 5 using the above calculated homography.