In [3]:

```
!pip install torchsummary
```

```
Collecting torchsummary
  Downloading torchsummary-1.5.1-py3-none-any.whl (2.8 kB)
Installing collected packages: torchsummary
Successfully installed torchsummary-1.5.1
```

In [4]:

```
import numpy as np

import scipy.io
import os
from numpy.linalg import norm,det,inv,svd
from scipy.linalg import rq
import math
import matplotlib.pyplot as plt
import numpy as np
import math
import random
import sys
from scipy import ndimage,spatial
from tqdm.notebook import trange,tqdm
import torch
import torch.nn as nn
import torch.optim as optim
from torch.optim import lr_scheduler
from torch.autograd import Variable
import torchvision
from torchvision import datasets,models,transforms
from  torch.utils.data import Dataset,DataLoader,ConcatDataset
from skimage import io,transform,data
from torchvision import transforms,utils
import  os
import sklearn.svm
import cv2
from os.path import exists
import pandas as pd
import PIL
from sklearn.metrics.cluster import completeness_score
from sklearn.cluster import KMeans
from tqdm import tqdm,tqdm_notebook
from functools import partial
from  torchsummary import summary
from torchvision.datasets import ImageFolder
from torch.utils.data.sampler import SubsetRandomSampler
```

In [5]:

```
class Image:
    def __init__(self,img,position):
        self.img = img
        self.position  = position

inliner_matchset = []
def features_matching(a,keypointlength,threshold):
    bestmatch = np.empty((keypointlength), dtype=np.int16)
    img1index = np.empty((keypointlength),dtype=np.init16)
    distance = np.empty((keypointlength))
    index =0
    for j in range(0,keypointlength):
        x=a[j]
        listx = x.tolist()
        x.sort()
        minval1=x[0]
        minval2=x[1]
```

```
        itemindex1 = listx.index(minval1)
        itemindex2 = listx.index(minval2)
        ratio = minval1/minval2

        if ratio < threshold:
            bestmatch[index] = itemindex1
            distance[index] = minval1
            img1index[index] = j
            index = index + 1
    return [cv2.DMatch(img1index[i],bestmatch[i].astype(int),distance[i]) for i in range
(0,index)]

def compute_Hmography(im1_pts,im2_pts):
    num_matches=len(im1_pts)
    num_rows = 2*num_matches
    num_cols = 9
    A_matrix_shape = (num_rows,num_cols)
    A = np.zeros(A_matrix_shape)
    a_index = 0
    for i in range(0,num_matches):
        (a_x,a_y) = im1_pts[i]
        (b_x,b_y) = im2_pts[i]
        row1 = [a_x,a_y,1,0,0,0,-b_x*a_x,-b_x*a_y,-b_x]
        row2 = [0,0,0,a_x,a_y,1,-b_y*a_x,-b_y*a_y,-b_y]
        A[a_index] = row1

        A[a_index+1] = row2
        a_index += 2

    U,s,Vt = np.linalg.svd(A)
    H = np.eye(3)
    H = Vt[-1].reshape(3,3)
    return H

def displayplot(img,title):
    plt.figure(figsize=(15,15))
    plt.title(title)
    plt.imshow(cv2.cvtColor(img,cv2.COLOR_BGR2RGB))
    plt.show()

def RANSAC_alg(f1,f2,matches,nRANSAC,RANSACthresh):
    minMatches = 4
    nBest = 0
    best_inliners = []
    H_estimate = np.eye(3,3)
    global inliner_matchset
    inliner_matchset = []
    for iteration in range(nRANSAC):
        matchSimple = random.sample(matches,minMatches)
        im1_pts = np.empty((minMatches,2))
        im2_pts = np.empty((minMatches,2))
        for i in range(0,minMatches):
            m  = matchSimple[i]
            im1_pts[i] = f1[m.queryIdx].pt
            im2_pts[i] = f2[m.trainIdx].pt

        H_estimate = compute_Hmography(im1_pts,im2_pts)
        inliners = get_inliners(f1,f2,matches,H_estimate,RANSACthresh)
        if len(inliners) > nBest:
            nBest = len(inliners)
            best_inliners= inliners

    print("Number of best inliners", len(best_inliners))
    for i in range(len(best_inliners)):
        inliner_matchset.append(matches[best_inliners[i]])
    im1_pts = np.empty((len(best_inliners),2))
    im2_pts = np.empty((len(best_inliners),2))
    for i in range(0,len(best_inliners)):
        m = inliner_matchset[i]
        im1_pts[i] = f1[m.queryIdx].pt
        im2_pts[i] = f2[m.trainIdx].pt
    M = compute_Hmography(im1_pts,im2_pts)
```

```
    return M, len(best_inliners)
```

In [1]:

```
!pip install opencv-python==3.4.2.17
!pip install opencv-contrib-python==3.4.2.17
```

```
Collecting opencv-python==3.4.2.17
  Downloading opencv_python-3.4.2.17-cp37-cp37m-manylinux1_x86_64.whl (25.0 MB)
     |████████████████████████████████| 25.0 MB 17.5 MB/s eta 0:00:01
Requirement already satisfied: numpy>=1.14.5 in /opt/conda/lib/python3.7/site-packages (f
rom opencv-python==3.4.2.17) (1.19.5)
Installing collected packages: opencv-python
  Attempting uninstall: opencv-python
    Found existing installation: opencv-python 4.5.1.48
    Uninstalling opencv-python-4.5.1.48:
      Successfully uninstalled opencv-python-4.5.1.48
Successfully installed opencv-python-3.4.2.17
Collecting opencv-contrib-python==3.4.2.17
  Downloading opencv_contrib_python-3.4.2.17-cp37-cp37m-manylinux1_x86_64.whl (30.6 MB)
     |████████████████████████████████| 30.6 MB 25.9 MB/s eta 0:00:01
Requirement already satisfied: numpy>=1.14.5 in /opt/conda/lib/python3.7/site-packages (f
rom opencv-contrib-python==3.4.2.17) (1.19.5)
Installing collected packages: opencv-contrib-python
Successfully installed opencv-contrib-python-3.4.2.17
```

In [2]:

```
import cv2
cv= cv2.xfeatures2d.SIFT_create()
```

In [6]:

```
files_all = os.listdir('../input/uni-campus-dataset/RGB-img/img/')
files_all.sort()

folder_path = '../input/uni-campus-dataset/RGB-img/img/'
left_files_path_rev = []
right_files_path = []
for file in files_all[:61]:
    left_files_path_rev.append(folder_path + file)


left_files_path = left_files_path_rev[::-1]


for file in files_all[61:100]:
    right_files_path.append(folder_path + file)
```

In [7]:

```
gridsize = 8
clahe = cv2.createCLAHE(clipLimit=2.0,tileGridSize=(gridsize,gridsize))
images_left_bgr = []
images_right_bgr = []
images_left = []
images_right = []


for file in tqdm(left_files_path):
    left_image_sat= cv2.imread(file)
    lab = cv2.cvtColor(left_image_sat, cv2.COLOR_BGR2LAB)
    lab[...,0] = clahe.apply(lab[...,0])
    left_image_sat = cv2.cvtColor(lab, cv2.COLOR_LAB2BGR)
    left_img = cv2.resize(left_image_sat,None,fx=0.35, fy=0.35, interpolation = cv2.INTE
R_CUBIC)
    images_left.append(cv2.cvtColor(left_img, cv2.COLOR_BGR2GRAY).astype('float32')/255.)
    images_left_bgr.append(left_img)


for file in tqdm(right_files_path):
```

```
    right_image_sat= cv2.imread(file)
    lab = cv2.cvtColor(right_image_sat, cv2.COLOR_BGR2LAB)
    lab[...,0] = clahe.apply(lab[...,0])
    right_image_sat = cv2.cvtColor(lab, cv2.COLOR_LAB2BGR)
    right_img = cv2.resize(right_image_sat,None,fx=0.35,fy=0.35, interpolation = cv2.INT
ER_CUBIC)
    images_right.append(cv2.cvtColor(right_img, cv2.COLOR_BGR2GRAY).astype('float32')/255
.)
    images_right_bgr.append(right_img)
```

```
100%|██████████| 61/61 [01:06<00:00,  1.08s/it]
100%|██████████| 39/39 [00:41<00:00,  1.07s/it]
```

In [8]:

```
images_left_bgr_no_enhance = []
images_right_bgr_no_enhance = []

for file in tqdm(left_files_path):
    left_image_sat= cv2.imread(file)
    left_img = cv2.resize(left_image_sat,None,fx=0.35, fy=0.35, interpolation = cv2.INTE
R_CUBIC)
    images_left_bgr_no_enhance.append(left_img)

for file in tqdm(right_files_path):
    right_image_sat= cv2.imread(file)
    right_img = cv2.resize(right_image_sat,None,fx=0.35,fy=0.35, interpolation = cv2.INT
ER_CUBIC)
    images_right_bgr_no_enhance.append(right_img)
```

```
100%|██████████| 61/61 [00:24<00:00,  2.49it/s]
100%|██████████| 39/39 [00:16<00:00,  2.43it/s]
```

In [ ]:

```
Threshl=60;
Octaves=8;
#PatternScales=1.0f;
brisk = cv2.BRISK_create(Threshl,Octaves)

keypoints_all_left_brisk = []
descriptors_all_left_brisk = []
points_all_left_brisk=[]


keypoints_all_right_brisk = []
descriptors_all_right_brisk = []
points_all_right_brisk=[]


for imgs in tqdm(images_left_bgr):
    kpt = brisk.detect(imgs,None)
    kpt,descrip = brisk.compute(imgs, kpt)
    keypoints_all_left_brisk.append(kpt)
    descriptors_all_left_brisk.append(descrip)
    points_all_left_brisk.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr):
    kpt = brisk.detect(imgs,None)
    kpt,descrip = brisk.compute(imgs, kpt)
    keypoints_all_right_brisk.append(kpt)
    descriptors_all_right_brisk.append(descrip)
    points_all_right_brisk.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

In [ ]:

```
orb = cv2.ORB_create(5000)
keypoints_all_left_orb = []
descriptors_all_left_orb = []
points_all_left_orb=[]
```

```
keypoints_all_right_orb = []
descriptors_all_right_orb = []
points_all_right_orb=[]

for imgs in tqdm(images_left_bgr):
    kpt = orb.detect(imgs,None)
    kpt,descrip = orb.compute(imgs, kpt)
    keypoints_all_left_orb.append(kpt)
    descriptors_all_left_orb.append(descrip)
    points_all_left_orb.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr):
    kpt = orb.detect(imgs,None)
    kpt,descrip = orb.compute(imgs, kpt)
    keypoints_all_right_orb.append(kpt)
    descriptors_all_right_orb.append(descrip)
    points_all_right_orb.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

In [27]:

```
kaze = cv2.KAZE_create()
keypoints_all_left_kaze = []
descriptors_all_left_kaze = []
points_all_left_kaze=[]

keypoints_all_right_kaze = []
descriptors_all_right_kaze = []
points_all_right_kaze=[]

for imgs in tqdm(images_left_bgr):
    kpt = kaze.detect(imgs,None)
    kpt,descrip = kaze.compute(imgs, kpt)
    keypoints_all_left_kaze.append(kpt)
    descriptors_all_left_kaze.append(descrip)
    points_all_left_kaze.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr):
    kpt = kaze.detect(imgs,None)
    kpt,descrip = kaze.compute(imgs, kpt)
    keypoints_all_right_kaze.append(kpt)
    descriptors_all_right_kaze.append(descrip)
    points_all_right_kaze.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

```
100%|██████████| 39/39 [04:41<00:00,  7.21s/it]
```

In [28]:

```
tqdm = partial(tqdm, position=0, leave=True)
```

In [10]:

```
akaze = cv2.AKAZE_create()
keypoints_all_left_akaze = []
descriptors_all_left_akaze = []
points_all_left_akaze=[]

keypoints_all_right_akaze = []
descriptors_all_right_akaze = []
points_all_right_akaze=[]

for imgs in tqdm(images_left_bgr):
    kpt = akaze.detect(imgs,None)
    kpt,descrip = akaze.compute(imgs, kpt)
    keypoints_all_left_akaze.append(kpt)
    descriptors_all_left_akaze.append(descrip)
    points_all_left_akaze.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
for imgs in tqdm(images_right_bgr):
    kpt = akaze.detect(imgs,None)
    kpt,descrip = akaze.compute(imgs, kpt)
    keypoints_all_right_akaze.append(kpt)
    descriptors_all_right_akaze.append(descrip)
```

```
    points_all_right_akaze.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

```
100%|██████████| 61/61 [01:24<00:00,  1.39s/it]
100%|██████████| 39/39 [00:52<00:00,  1.34s/it]
```

In [ ]:

```
star = cv2.xfeatures2d.StarDetector_create()
brief = cv2.xfeatures2d.BriefDescriptorExtractor_create()
keypoints_all_left_star = []
descriptors_all_left_brief = []
points_all_left_star=[]


keypoints_all_right_star = []
descriptors_all_right_brief = []
points_all_right_star=[]

for imgs in tqdm(images_left_bgr):
    kpt = star.detect(imgs,None)
    kpt,descrip = brief.compute(imgs, kpt)
    keypoints_all_left_star.append(kpt)
    descriptors_all_left_brief.append(descrip)
    points_all_left_star.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr):
    kpt = star.detect(imgs,None)
    kpt,descrip = brief.compute(imgs, kpt)
    keypoints_all_right_star.append(kpt)
    descriptors_all_right_brief.append(descrip)
    points_all_right_star.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

In [ ]:

```
Threshl=60;
Octaves=8;
#PatternScales=1.0f;
brisk = cv2.BRISK_create(Threshl,Octaves)
freak = cv2.xfeatures2d.FREAK_create()
keypoints_all_left_freak = []
descriptors_all_left_freak = []
points_all_left_freak=[]


keypoints_all_right_freak = []
descriptors_all_right_freak = []
points_all_right_freak=[]

for imgs in tqdm(images_left_bgr):
    kpt = brisk.detect(imgs)
    kpt,descrip = freak.compute(imgs, kpt)
    keypoints_all_left_freak.append(kpt)
    descriptors_all_left_freak.append(descrip)
    points_all_left_freak.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr):
    kpt = brisk.detect(imgs,None)
    kpt,descrip = freak.compute(imgs, kpt)
    keypoints_all_right_freak.append(kpt)
    descriptors_all_right_freak.append(descrip)
    points_all_right_freak.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

In [ ]:

```
mser = cv2.MSER_create()
sift = cv2.xfeatures2d.SIFT_create()
keypoints_all_left_mser = []
descriptors_all_left_mser = []
points_all_left_mser=[]

keypoints_all_right_mser = []
```

```
descriptors_all_right_mser = []
points_all_right_mser=[]
for imgs in tqdm(images_left_bgr_no_enhance):
    kpt = mser.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_left_mser.append(kpt)
    descriptors_all_left_mser.append(descrip)
    points_all_left_mser.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))


for imgs in tqdm(images_right_bgr_no_enhance):
    kpt = mser.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_right_mser.append(kpt)
    descriptors_all_right_mser.append(descrip)
    points_all_right_mser.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

In [10]:

```
agast = cv2.AgastFeatureDetector_create()
sift = cv2.xfeatures2d.SIFT_create()
keypoints_all_left_agast = []
descriptors_all_left_agast = []
points_all_left_agast=[]

keypoints_all_right_agast = []
descriptors_all_right_agast = []
points_all_right_agast=[]


for imgs in tqdm(images_left_bgr_no_enhance):
    kpt = agast.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_left_agast.append(kpt)
    descriptors_all_left_agast.append(descrip)
    points_all_left_agast.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))


for imgs in tqdm(images_right_bgr_no_enhance):
    kpt = agast.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_right_agast.append(kpt)
    descriptors_all_right_agast.append(descrip)
    points_all_right_agast.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

```
100%|██████████| 61/61 [08:11<00:00,  8.05s/it]
100%|██████████| 39/39 [05:24<00:00,  8.33s/it]
```

In [ ]:

```
fast = cv2.FastFeatureDetector_create()
sift = cv2.xfeatures2d.SIFT_create()
keypoints_all_left_fast = []
descriptors_all_left_fast = []
points_all_left_fast=[]

keypoints_all_right_fast = []
descriptors_all_right_fast = []
points_all_right_fast=[]
for imgs in tqdm(images_left_bgr_no_enhance):
    kpt = fast.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_left_fast.append(kpt)
    descriptors_all_left_fast.append(descrip)
    points_all_left_fast.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr_no_enhance):
    kpt = fast.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_right_fast.append(kpt)
    descriptors_all_right_fast.append(descrip)
```

```
    points_all_right_fast.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

In [10]:

```
gftt = cv2.GFTTDetector_create()
sift = cv2.xfeatures2d.SIFT_create()
keypoints_all_left_gftt = []
descriptors_all_left_gftt = []
points_all_left_gftt=[]

keypoints_all_right_gftt = []
descriptors_all_right_gftt = []
points_all_right_gftt=[]
for imgs in tqdm(images_left_bgr_no_enhance):
    kpt = gftt.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_left_gftt.append(kpt)
    descriptors_all_left_gftt.append(descrip)
    points_all_left_gftt.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr_no_enhance):
    kpt = gftt.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_right_gftt.append(kpt)
    descriptors_all_right_gftt.append(descrip)
    points_all_right_gftt.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

```
100%|██████████| 61/61 [00:14<00:00,  4.11it/s]
100%|██████████| 39/39 [00:09<00:00,  4.11it/s]
```

In [10]:

```
daisy = cv2.xfeatures2d.DAISY_create()
sift = cv2.xfeatures2d.SIFT_create()
keypoints_all_left_daisy = []
descriptors_all_left_daisy = []
points_all_left_daisy=[]

keypoints_all_right_daisy = []
descriptors_all_right_daisy = []
points_all_right_daisy=[]

for imgs in tqdm(images_left_bgr_no_enhance):
    kpt = sift.detect(imgs,None)
    kpt,descrip = daisy.compute(imgs, kpt)
    keypoints_all_left_daisy.append(kpt)
    descriptors_all_left_daisy.append(descrip)
    points_all_left_daisy.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr_no_enhance):
    kpt = sift.detect(imgs,None)
    kpt,descrip = daisy.compute(imgs, kpt)
    keypoints_all_right_daisy.append(kpt)
    descriptors_all_right_daisy.append(descrip)
    points_all_right_daisy.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

```
100%|██████████| 61/61 [01:39<00:00,  1.63s/it]
100%|██████████| 39/39 [01:03<00:00,  1.63s/it]
```

In [13]:

```
surf = cv2.xfeatures2d.SURF_create()
sift = cv2.xfeatures2d.SIFT_create()
keypoints_all_left_surfsift = []
descriptors_all_left_surfsift = []
points_all_left_surfsift=[]

keypoints_all_right_surfsift = []
descriptors_all_right_surfsift = []
points_all_right_surfsift=[]
```

```
for imgs in tqdm(images_left_bgr_no_enhance):
    kpt = surf.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_left_surfsift.append(kpt)
    descriptors_all_left_surfsift.append(descrip)
    points_all_left_surfsift.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr_no_enhance):
    kpt = surf.detect(imgs,None)

    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_right_surfsift.append(kpt)
    descriptors_all_right_surfsift.append(descrip)
    points_all_right_surfsift.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

```
100%|██████████| 61/61 [15:38<00:00, 15.39s/it]
100%|██████████| 39/39 [10:21<00:00, 15.94s/it]
```

In [10]:

```
sift = cv2.xfeatures2d.SIFT_create()
keypoints_all_left_sift = []
descriptors_all_left_sift = []
points_all_left_sift=[]

keypoints_all_right_sift = []
descriptors_all_right_sift = []
points_all_right_sift=[]

for imgs in tqdm(images_left_bgr_no_enhance):
    kpt = sift.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_left_sift.append(kpt)
    descriptors_all_left_sift.append(descrip)
    points_all_left_sift.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr_no_enhance):
    kpt = sift.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_right_sift.append(kpt)
    descriptors_all_right_sift.append(descrip)
    points_all_right_sift.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

```
100%|██████████| 61/61 [02:20<00:00,  2.30s/it]
100%|██████████| 39/39 [01:33<00:00,  2.40s/it]
```

In [27]:

```
surf = cv2.xfeatures2d.SURF_create()
keypoints_all_left_surf = []
descriptors_all_left_surf = []
points_all_left_surf=[]

keypoints_all_right_surf = []
descriptors_all_right_surf = []
points_all_right_surf=[]
for imgs in tqdm(images_left_bgr):
    kpt = surf.detect(imgs,None)
    kpt,descrip = surf.compute(imgs, kpt)
    keypoints_all_left_surf.append(kpt)
    descriptors_all_left_surf.append(descrip)
    points_all_left_surf.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))

for imgs in tqdm(images_right_bgr):
    kpt = surf.detect(imgs,None)
    kpt,descrip = surf.compute(imgs, kpt)
    keypoints_all_right_surf.append(kpt)
    descriptors_all_right_surf.append(descrip)
    points_all_right_surf.append(np.asarray([[p.pt[0],p.pt[1]] for p in kpt]))
```

```
100%|██████████| 61/61 [07:41<00:00,  7.57s/it]
100%|██████████| 39/39 [04:48<00:00,  7.39s/it]
```

In [ ]:

```
# sift  = cv2.xfeatures2d.SURF_Create()
# keypoints_all_left_surf = []
# descriptor_all_left_surf = []
# points_all_left_surf = []

# keypoints_all_right_surf = []
# descriptor_all_right_surf = []
# points_all_right_surf = []

#  for images in tqdm(left_images_bgr):
#  kpt = surf.detect(imgs,None)
# kpt, descrip = surf.compute(imgs,kpt)
# keypoints_all_left_surf.append(kpt)
#descriptor_all_left_surf.append(descrip)
#points_all_left_surf.append(np.asarray([[p.pt[0],p.pt[1]] for p in kpt])
#  points_all_left_surf.append(np.asarray([[p.pt[0], p.pt[1] for p in  kpt]]))
```

In [ ]:

```
class RootSIFT:
    def __init__(self):
        # initialize the SIFT feature extractor
        #self.extractor = cv2.DescriptorExtractor_create("SIFT")
        self.sift = cv2.xfeatures2d.SIFT_create()
    def compute(self, image, kps, eps=1e-7):
        # compute SIFT descriptors
        (kps, descs) = self.sift.compute(image, kps)
        # if there are no keypoints or descriptors, return an empty tuple
        if len(kps) == 0:
            return ([], None)
        # apply the Hellinger kernel by first L1-normalizing, taking the
        # square-root, and then L2-normalizing
        descs /= (np.linalg.norm(descs, axis=0, ord=2) + eps)
        descs /= (descs.sum(axis=0) + eps)
        descs = np.sqrt(descs)
        #descs /= (np.linalg.norm(descs, axis=0, ord=2) + eps)
        # return a tuple of the keypoints and descriptors
        return (kps, descs)
```

In [ ]:

```
sift = cv2.xfeatures2d.SIFT_create()
rootsift = RootSIFT()
keypoints_all_left_rootsift = []
descriptors_all_left_rootsift = []
points_all_left_rootsift=[]

keypoints_all_right_rootsift = []
descriptors_all_right_rootsift = []
points_all_right_rootsift=[]

for imgs in tqdm(images_left_bgr):
    kpt = sift.detect(imgs,None)
    kpt,descrip = rootsift.compute(imgs, kpt)
    keypoints_all_left_rootsift.append(kpt)
    descriptors_all_left_rootsift.append(descrip)
    points_all_left_rootsift.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
for imgs in tqdm(images_right_bgr):
    kpt = sift.detect(imgs,None)
    kpt,descrip = rootsift.compute(imgs, kpt)
    keypoints_all_right_rootsift.append(kpt)
    descriptors_all_right_rootsift.append(descrip)
    points_all_right_rootsift.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```

In [11]:

```
!git clone https://github.com/magicleap/SuperPointPretrainedNetwork.git
```

```
Cloning into 'SuperPointPretrainedNetwork'
```

```
Cloning into 'SuperPointPretrainedNetwork' ...
remote: Enumerating objects: 81, done.
remote: Total 81 (delta 0), reused 0 (delta 0), pack-reused 81
Unpacking objects: 100% (81/81), done.
```

In [12]:

```
weights_path = 'SuperPointPretrainedNetwork/superpoint_v1.pth'
cuda = 'True'
```

In [13]:

```
def to_kpts(pts,size=1):
    return [cv2.KeyPoint(pt[0],pt[1],size) for pt in pts]
```

In [14]:

```
torch.cuda.empty_cache()
class SuperPointNet(nn.Module):
    def __init__(self):
        super(SuperPointNet,self).__init__()
        self.relu = nn.ReLU(inplace=True)
        self.pool = nn.MaxPool2d(kernel_size=2, stride=2)
        c1,c2,c3,c4,c5,d1 = 64,64,128,128,256,256
        self.conv1a = nn.Conv2d(1,c1,kernel_size=3,stride=1,padding=1)
        self.conv1b = nn.Conv2d(c1,c1,kernel_size=3,stride=1,padding=1)
        self.conv2a = nn.Conv2d(c1,c2,kernel_size=3,stride=1,padding=1)
        self.conv2b = nn.Conv2d(c2,c2,kernel_size=3,stride=1,padding=1)
        self.conv3a = nn.Conv2d(c2,c3,kernel_size=3,stride=1,padding=1)
        self.conv3b = nn.Conv2d(c3,c3,kernel_size=3,stride=1,padding=1)
        self.conv4a = nn.Conv2d(c3,c4,kernel_size=3,stride=1,padding=1)
        self.conv4b = nn.Conv2d(c4,c4,kernel_size=3,stride=1,padding=1)
        self.convPa = nn.Conv2d(c4,c5,kernel_size=3,stride=1,padding=1)
        self.convPb = nn.Conv2d(c5,65,kernel_size=1,stride=1,padding=0)
        self.convDa = nn.Conv2d(c4,c5,kernel_size=3,stride=1,padding=1)


        self.convDb = nn.Conv2d(c5,d1,kernel_size=1,stride=1,padding=0)

    def forward(self,x):
        x = self.relu(self.conv1a(x))
        x = self.relu(self.conv1b(x))
        x = self.pool(x)
        x = self.relu(self.conv2a(x))
        x = self.relu(self.conv2b(x))
        x = self.pool(x)
        x  = self.relu(self.conv3a(x))
        x = self.relu(self.conv3b(x))
        x = self.pool(x)
        x = self.relu(self.conv4a(x))
        x = self.relu(self.conv4b(x))
        cPa = self.relu(self.convPa(x))
        semi = self.convPb(cPa)
        cDa = self.relu(self.convDa(x))
        desc = self.convDb(cDa)
        dn = torch.norm(desc,p=2,dim=1)
        desc = desc.div(torch.unsqueeze(dn,1))
        return semi,desc


class SuperPointFrontend(object):
    def __init__(self,weights_path,nms_dist,conf_thresh, nn_thresh,cuda=True):
        self.name = 'SuperPoint'
        self.cuda = cuda
        self.nms_dist = nms_dist
        self.conf_thresh = conf_thresh
        self.nn_thresh = nn_thresh
        self.cell = 8
        self.border_remove = 4

        self.net = SuperPointNet()
        if cuda:
```

```
            self.net.load_state_dict(torch.load(weights_path))
            self.net = self.net.cuda()
        else:
            self.net.load_state_dict(torch.load(weights_path,map_location=lambda storage
, loc: storage))
        self.net.eval()

    def nms_fast(self,in_corners,H,W,dist_thresh):
        grid = np.zeros((H,W)).astype(int)
        inds = np.zeros((H,W)).astype(int)
        inds1 = np.argsort(-in_corners[2,:])
        corners  = in_corners[:,inds1]
        rcorners = corners[:2,:].round().astype(int)
        if rcorners.shape[1] == 0:
            return np.zeros((3,0)).astype(int), np.zeros(0).astype(int)
        if rcorners.shape[1] == 1:
            out =  np.vstack((rcorners,in_corners[2])).reshape(3,1)
            return out,np.zeros((1)).astype(int)
        for i, rc in enumerate(rcorners.T):
            grid[rcorners[1,i],rcorners[0,i]] =1
            inds[rcorners[1,i],rcorners[0,i]] =i
        pad = dist_thresh
        grid = np.pad(grid,((pad,pad),(pad,pad)),mode='constant')
        count = 0
        for i,rc  in enumerate(rcorners.T):
            pt = (rc[0]+pad, rc[1]+pad)
            if grid[pt[1], pt[0]] == 1:
                grid[pt[1]-pad:pt[1]+pad+1, pt[0]-pad:pt[0]+pad+1]=0


                grid[pt[1], pt[0]] = -1
                count += 1

        keepy, keepx = np.where(grid==-1)
        keepy,keepx = keepy-pad , keepx-pad
        inds_keep = inds[keepy, keepx]
        out  = corners[:,inds_keep]
        values = out[-1,:]
        inds2 = np.argsort(-values)
        out = out[:,inds2]
        out_inds = inds1[inds_keep[inds2]]
        return out, out_inds

    def run(self,img):
        assert img.ndim == 2
        assert img.dtype == np.float32
        H,W = img.shape[0], img.shape[1]
        inp = img.copy()
        inp = (inp.reshape(1,H,W))
        inp = torch.from_numpy(inp)
        inp = torch.autograd.Variable(inp).view(1,1,H,W)
        if self.cuda:
            inp = inp.cuda()
        outs = self.net.forward(inp)
        semi,coarse_desc = outs[0],outs[1]
        semi = semi.data.cpu().numpy().squeeze()


        dense = np.exp(semi)
        dense = dense / (np.sum(dense,axis=0)+.00001)
        nodust = dense[:-1,:,:]
        Hc = int(H / self.cell)
        Wc = int(W  / self.cell)
        nodust = np.transpose(nodust,[1,2,0])
        heatmap = np.reshape(nodust,[Hc,Wc,self.cell,self.cell])
        heatmap = np.transpose(heatmap,[0,2,1,3])
        heatmap = np.reshape(heatmap,[Hc*self.cell, Wc*self.cell])
        prob_map  = heatmap/np.sum(np.sum(heatmap))

        return heatmap,coarse_desc

    def key_pt_sampling(self,img,heat_map,coarse_desc,sampled):
```

```
        H,W = img.shape[0], img.shape[1]
        xs,ys = np.where(heat_map >= self.conf_thresh)
        if len(xs) == 0:
            return np.zeros((3,0)),None,None
        print("Number of pts selected:",len(xs))

        pts = np.zeros((3,len(xs)))
        pts[0,:] = ys
        pts[1,:] = xs
        pts[2,:] = heat_map[xs,ys]
        pts,_ = self.nms_fast(pts,H,W,dist_thresh=self.nms_dist)
        inds = np.argsort(pts[2,:])
        pts = pts[:,inds[::-1]]
        bord = self.border_remove
        toremoveW = np.logical_or(pts[0,:] < bord, pts[0,:] >= (W-bord))
        toremoveH = np.logical_or(pts[1,:] < bord, pts[0,:] >= (H-bord))
        toremove = np.logical_or(toremoveW, toremoveH)
        pts = pts[:,~toremove]
        pts = pts[:,0:sampled]
        D = coarse_desc.shape[1]
        if pts.shape[1] == 0:
            desc = np.zeros((D,0))
        else:
            samp_pts = torch.from_numpy(pts[:2,:].copy())
            samp_pts[0,:] = (samp_pts[0,:] / (float(W)/2.))-1.
            samp_pts[1,:] = (samp_pts[1,:] / (float(W)/2.))-1.
            samp_pts = samp_pts.transpose(0,1).contiguous()
            samp_pts = samp_pts.view(1,1,-1,2)
            samp_pts = samp_pts.float()
            if self.cuda:
                samp_pts = samp_pts.cuda()
            desc = nn.functional.grid_sample(coarse_desc, samp_pts)
            desc = desc.data.cpu().numpy().reshape(D,-1)
            desc /= np.linalg.norm(desc,axis=0)[np.newaxis,:]
        return pts,desc
```

In [15]:

```
print('Load pre trained network')
fe = SuperPointFrontend(weights_path = weights_path, nms_dist = 4, conf_thresh  = 0.015,
nn_thresh=0.7,
                        cuda = cuda)
print('Successfully  loaded pretrained network')
```

```
Load pre trained network
Successfully  loaded pretrained network
```

In [ ]:

```
keypoint_all_left_superpoint = []
descriptor_all_left_superpoint = []
point_all_left_superpoint = []

keypoints_all_right_superpoint = []
descriptors_all_right_superpoint = []
points_all_right_superpoint = []

for ifpth in tqdm(images_left):
    heatmap1, coarse_desc1 = fe.run(ifpth)
    pts_1, desc_1 = fe.key_pt_sampling(ifpth,heatmap1,coarse_desc1,2000)

    keypoint_all_left_superpoint.append(to_kpts(pts_1.T))
    descriptor_all_left_superpoint.append(desc_1.T)
    point_all_left_superpoint.append(pts_1.T)




for rfpth in tqdm(images_right):
    heatmap1, coarse_desc1 = fe.run(rfpth)
```

```
    pts_1, desc_1 = fe.key_pt_sampling(rfpth,heatmap1,coarse_desc1,2000)

    keypoints_all_right_superpoint.append(to_kpts(pts_1.T))
    descriptors_all_right_superpoint.append(desc_1.T)
    points_all_right_superpoint.append(pts_1.T)
```

In [ ]:

```
num_kps_brisk = []
for j in tqdm(keypoints_all_left_brisk + keypoints_all_right_brisk):
    num_kps_brisk.append(len(j))
```

In [ ]:

```
num_kps_orb = []
for j  in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
    num_kps_orb.append(len(j))
```

In [ ]:

```
num_kps_fast = []
for j in tqdm(keypoints_all_left_fast + keypoints_all_right_fast):
    num_kps_fast.append(len(j))
```

In [29]:

```
num_kps_kaze = []
for j  in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):
    num_kps_kaze.append(len(j))
```

```
100%|██████████| 100/100 [00:00<00:00, 440115.84it/s]
```

In [16]:

```
num_kps_akaze  = []




for j in tqdm(keypoints_all_left_akaze + keypoints_all_right_akaze):
    num_kps_akaze.append(len(j))
```

```
100%|██████████| 100/100 [00:00<00:00, 173175.23it/s]
```

In [ ]:

```
num_kps_freak = []
for j in tqdm(keypoints_all_left_freak + keypoints_all_right_freak):
    num_kps_freak.append(len(j))
```

In [ ]:

```
num_kps_mser =[]
for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
    num_kps_mser.append(len(j))
```

In [17]:

```
num_kps_gftt =[]
for j in tqdm(keypoints_all_left_gftt + keypoints_all_right_gftt):
    num_kps_gftt.append(len(j))
```

```
100%|██████████| 100/100 [00:00<00:00, 332090.58it/s]
```

In [16]:

```
num_kps_daisy = []
for  j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
    num_kps_daisy.append(j)
```

```
100%|██████████| 100/100 [00:00<00:00, 391259.70it/s]
```

In [ ]:

```
num_kps_star = []
for  j in tqdm(keypoints_all_left_star + keypoints_all_right_star):
    num_kps_star.append(len(j))
```

In [16]:

```
num_kps_sift = []
for j in tqdm(keypoints_all_left_sift + keypoints_all_right_sift):
    num_kps_sift.append(len(j))
```

```
100%|██████████| 100/100 [00:00<00:00, 432402.47it/s]
```

In [28]:

```
num_kps_surf = []
for j in tqdm(keypoints_all_left_surf + keypoints_all_right_surf):
    num_kps_surf.append(len(j))
```

```
100%|██████████| 100/100 [00:00<00:00, 398698.10it/s]
```

In [19]:

```
num_kps_surfsift = []
for j in tqdm(keypoints_all_left_surfsift + keypoints_all_right_surfsift):
    num_kps_surfsift.append(len(j))
```

```
100%|██████████| 100/100 [00:00<00:00, 255127.98it/s]
```

In [17]:

```
num_kps_agast  = []
for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):
    num_kps_agast.append(len(j))
```

```
100%|██████████| 100/100 [00:00<00:00, 200396.75it/s]
```

In [17]:

```
def compute_homography_fast(matched_pts1, matched_pts2,thresh=4):
    #matched_pts1 = cv2.KeyPoint_convert(matched_kp1)
    #matched_pts2 = cv2.KeyPoint_convert(matched_kp2)
    # Estimate the homography between the matches using RANSAC
    H, inliers = cv2.findHomography(matched_pts1,matched_pts2,cv2.RANSAC, ransacReprojTh
reshold =thresh)
    inliers = inliers.flatten()
    return H, inliers
```

In [18]:

```
def get_Hmatrix(imgs,keypts,pts,descripts,ratio=0.8,thresh=4,disp=False):
    FLANN_INDEX_KDTREE = 2
    index_params = dict(algorithm=FLANN_INDEX_KDTREE, trees=5)
    search_params = dict(checks=50)
    flann = cv2.FlannBasedMatcher(index_params, search_params)
    #flann = cv2.BFMatcher()
    lff1 = np.float32(descripts[0])
    lff = np.float32(descripts[1])
    matches_lf1_lf = flann.knnMatch(lff1, lff, k=2)
    print("\nNumber of matches",len(matches_lf1_lf))
    matches_4 = []
    ratio = ratio
    # loop over the raw matches
    for m in matches_lf1_lf:
        # ensure the distance is within a certain ratio of each
        # other (i.e. Lowe's ratio test)
        if len(m) == 2 and m[0].distance < m[1].distance * ratio:

            matches_4.append(m[0])
```

```
    print("Number of matches After Lowe's Ratio",len(matches_4))
    matches_idx = np.array([m.queryIdx for m in matches_4])
    imm1_pts = np.array([keypts[0][idx].pt for idx in matches_idx])
    matche_idx = np.array([m.trainIdx for m in matches_4])
    imm2_pts = np.array([keypts[1][idx].pt for idx in matche_idx])

    '''
    # Estimate homography 1
    #Compute H1
    # Estimate homography 1
    #Compute H1
    imm1_pts=np.empty((len(matches_4),2))
    imm2_pts=np.empty((len(matches_4),2))
    for i in range(0,len(matches_4)):
    m = matches_4[i]
    (a_x, a_y) = keypts[0][m.queryIdx].pt
    (b_x, b_y) = keypts[1][m.trainIdx].pt
    imm1_pts[i]=(a_x, a_y)
    imm2_pts[i]=(b_x, b_y)
    H=compute_Homography(imm1_pts,imm2_pts)
    #Robustly estimate Homography 1 using RANSAC
    Hn, best_inliers=RANSAC_alg(keypts[0] ,keypts[1], matches_4, nRANSAC=1000, RANSACthre
sh=6)
    '''
    Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts)

    inlier_matchset = np.array(matches_4)[inliers.astype(bool)].tolist()
    print("Number of Robust matches",len(inlier_matchset))
    print("\n")
    '''
    if len(inlier_matchset)<50:
        matches_4 = []
        ratio = 0.67
        # loop over the raw matches
        for m in matches_lf1_lf:
           # ensure the distance is within a certain ratio of each
           # other (i.e. Lowe's ratio test)
           if len(m) == 2 and m[0].distance < m[1].distance * ratio:
           #matches_1.append((m[0].trainIdx, m[0].queryIdx))
           matches_4.append(m[0])
        print("Number of matches After Lowe's Ratio New",len(matches_4))
        matches_idx = np.array([m.queryIdx for m in matches_4])
        imm1_pts = np.array([keypts[0][idx].pt for idx in matches_idx])
        matches_idx = np.array([m.trainIdx for m in matches_4])
        imm2_pts = np.array([keypts[1][idx].pt for idx in matches_idx])
        Hn,inliers = compute_homography_fast_other(imm1_pts,imm2_pts)
        inlier_matchset = np.array(matches_4)[inliers.astype(bool)].tolist()
        print("Number of Robust matches New",len(inlier_matchset))
        print("\n")
       '''
    #H=compute_Homography(imm1_pts,imm2_pts)
    #Robustly estimate Homography 1 using RANSAC
    #Hn=RANSAC_alg(keypts[0] ,keypts[1], matches_4, nRANSAC=1500, RANSACthresh=6)
    #global inlier_matchset
    if disp==True:
        dispimg1=cv2.drawMatches(imgs[0], keypts[0], imgs[1], keypts[1], inlier_matchset
, None,flags=2)
        displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')
    return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)
```

In [19]:

```
from functools import partial
from tqdm import tqdm
tqdm = partial(tqdm, position=0, leave=True)
```

In [ ]:

```
H_left_brisk = []
H_right_brisk = []
```

```
num_matches_brisk = []
num_good_matches_brisk = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_brisk[j:j+2][::-1],points_all_left_brisk[j:j+2][::-1],descriptors_all_left_brisk[j:j+2]
[::-1])
    H_left_brisk.append(H_a)
    num_matches_brisk.append(matches)
    num_good_matches_brisk.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_brisk[j:j+2][::-1],points_all_right_brisk[j:j+2][::-1],descriptors_all_right_brisk[j:
j+2][::-1])
    H_right_brisk.append(H_a)
    num_matches_brisk.append(matches)
    num_good_matches_brisk.append(gd_matches)
```

In [ ]:

```
H_left_orb = []
H_right_orb = []

num_matches_orb = []
num_good_matches_orb = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_orb[j:j+2][::-1],points_all_left_orb[j:j+2][::-1],descriptors_all_left_orb[j:j+2][::-1]
)
    H_left_orb.append(H_a)
    num_matches_orb.append(matches)
    num_good_matches_orb.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_orb[j:j+2][::-1],points_all_right_orb[j:j+2][::-1],descriptors_all_right_orb[j:j+2][:
:-1])
    H_right_orb.append(H_a)
    num_matches_orb.append(matches)
    num_good_matches_orb.append(gd_matches)
```

In [ ]:

```
H_left_akaze = []
H_right_akaze = []

num_matches_akaze = []
num_good_matches_akaze = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_akaze[j:j+2][::-1],points_all_left_akaze[j:j+2][::-1],descriptors_all_left_akaze[j:j+2]
[::-1])
    H_left_akaze.append(H_a)
```

```
    num_matches_akaze.append(matches)
    num_good_matches_akaze.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_akaze[j:j+2][::-1],points_all_right_akaze[j:j+2][::-1],descriptors_all_right_akaze[j:
j+2][::-1])
    H_right_akaze.append(H_a)
    num_matches_akaze.append(matches)
    num_good_matches_akaze.append(gd_matches)
```

In [ ]:

```
H_left_kaze = []
H_right_kaze = []

num_matches_kaze = []
num_good_matches_kaze = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_kaze[j:j+2][::-1],points_all_left_kaze[j:j+2][::-1],descriptors_all_left_kaze[j:j+2][::
-1])
    H_left_kaze.append(H_a)
    num_matches_kaze.append(matches)
    num_good_matches_kaze.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_kaze[j:j+2][::-1],points_all_right_kaze[j:j+2][::-1],descriptors_all_right_kaze[j:j+2
][::-1])
    H_right_kaze.append(H_a)
    num_matches_kaze.append(matches)
    num_good_matches_kaze.append(gd_matches)
```

In [ ]:

```
H_left_freak = []
H_right_freak = []

num_matches_freak = []
num_good_matches_freak = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_freak[j:j+2][::-1],points_all_left_freak[j:j+2][::-1],descriptors_all_left_freak[j:j+2]
[::-1])
    H_left_freak.append(H_a)
    num_matches_freak.append(matches)
    num_good_matches_freak.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_freak[j:j+2][::-1],points_all_right_freak[j:j+2][::-1],descriptors_all_right_freak[j:
j+2][::-1])
    H_right_freak.append(H_a)
```

```
    num_matches_freak.append(matches)
    num_good_matches_freak.append(gd_matches)
```

In [ ]:

```
H_left_mser = []
H_right_mser = []

num_matches_mser = []
num_good_matches_mser = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_mser[j:j+2][::-1],points_all_left_mser[j:j+2][::-1],descriptors_all_left_mser[j:j+2][::
-1])
    H_left_mser.append(H_a)
    num_matches_mser.append(matches)
    num_good_matches_mser.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_mser[j:j+2][::-1],points_all_right_mser[j:j+2][::-1],descriptors_all_right_mser[j:j+2
][::-1])
    H_right_mser.append(H_a)
    num_matches_mser.append(matches)
    num_good_matches_mser.append(gd_matches)
```

In [21]:

```
H_left_gftt = []
H_right_gftt = []

num_matches_gftt = []
num_good_matches_gftt = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_gftt[j:j+2][::-1],points_all_left_gftt[j:j+2][::-1],descriptors_all_left_gftt[j:j+2][::
-1])
    H_left_gftt.append(H_a)
    num_matches_gftt.append(matches)
    num_good_matches_gftt.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_gftt[j:j+2][::-1],points_all_right_gftt[j:j+2][::-1],descriptors_all_right_gftt[j:j+2
][::-1])
    H_right_gftt.append(H_a)
    num_matches_gftt.append(matches)
    num_good_matches_gftt.append(gd_matches)
```

```
  3%|▌          | 2/61 [00:00<00:05, 10.58it/s]
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 179
Number of Robust matches 70



Number of matches 1000
```

```
Number of matches After Lowe's Ratio 96
Number of Robust matches 31



Number of matches 1000
Number of matches After Lowe's Ratio 31
  7%|▋         | 4/61 [00:00<00:05,  9.79it/s]
Number of Robust matches 6



Number of matches 1000
Number of matches After Lowe's Ratio 302
Number of Robust matches 185



Number of matches 1000
Number of matches After Lowe's Ratio 161
Number of Robust matches 80


 13%|█▎        | 8/61 [00:00<00:05, 10.45it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 183
Number of Robust matches 96



Number of matches 1000
Number of matches After Lowe's Ratio 129
Number of Robust matches 62



Number of matches 1000
Number of matches After Lowe's Ratio 205
Number of Robust matches 107


 16%|█▌        | 10/61 [00:00<00:04, 10.81it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 183
Number of Robust matches 127



Number of matches 1000
Number of matches After Lowe's Ratio 151
Number of Robust matches 101



Number of matches 1000
Number of matches After Lowe's Ratio 275
Number of Robust matches 207


 23%|██▎       | 14/61 [00:01<00:04, 11.11it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 71
Number of Robust matches 26
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 162
Number of Robust matches 124



Number of matches 1000
Number of matches After Lowe's Ratio 234
Number of Robust matches 175


 26%|██        | 16/61 [00:01<00:04, 10.38it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 329
Number of Robust matches 274



Number of matches 1000
Number of matches After Lowe's Ratio 322
Number of Robust matches 243


 30%|██        | 18/61 [00:01<00:04,  9.08it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 347
Number of Robust matches 260



Number of matches 1000
Number of matches After Lowe's Ratio 381
Number of Robust matches 290


 33%|███       | 20/61 [00:02<00:04,  8.29it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 425
Number of Robust matches 283



Number of matches 1000
Number of matches After Lowe's Ratio 319
Number of Robust matches 260


 36%|███       | 22/61 [00:02<00:04,  9.19it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 183
Number of Robust matches 122



Number of matches 1000
Number of matches After Lowe's Ratio 355
Number of Robust matches 274



Number of matches 1000
Number of matches After Lowe's Ratio 183
Number of Robust matches 140
```

```
 43%|████      | 26/61 [00:02<00:03, 10.32it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 357
Number of Robust matches 280



Number of matches 1000
Number of matches After Lowe's Ratio 16
Number of Robust matches 5



Number of matches 1000
Number of matches After Lowe's Ratio 49
Number of Robust matches 31


 46%|████      | 28/61 [00:02<00:03, 10.63it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 334
Number of Robust matches 222



Number of matches 1000
Number of matches After Lowe's Ratio 72
Number of Robust matches 30



Number of matches 1000
Number of matches After Lowe's Ratio 55
Number of Robust matches 26


 49%|████      | 30/61 [00:02<00:02, 10.66it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 249
Number of Robust matches 160



Number of matches 1000
Number of matches After Lowe's Ratio 124
Number of Robust matches 81



Number of matches 1000
Number of matches After Lowe's Ratio 27
 52%|█████     | 32/61 [00:03<00:02, 10.19it/s]
Number of Robust matches 5



Number of matches 1000
Number of matches After Lowe's Ratio 368
Number of Robust matches 186


 57%|█████     | 35/61 [00:03<00:03,  8.59it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 389
```

```
Number of Robust matches 203



Number of matches 1000
Number of matches After Lowe's Ratio 325
Number of Robust matches 190


 61%|██████    | 37/61 [00:03<00:02,  8.07it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 350
Number of Robust matches 205



Number of matches 1000
Number of matches After Lowe's Ratio 337
Number of Robust matches 150


 64%|██████▍   | 39/61 [00:04<00:03,  7.12it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 313
Number of Robust matches 150



Number of matches 1000
Number of matches After Lowe's Ratio 267
Number of Robust matches 133


 67%|██████▋   | 41/61 [00:04<00:02,  7.26it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 373
Number of Robust matches 256



Number of matches 1000
Number of matches After Lowe's Ratio 396
Number of Robust matches 326


 70%|███████   | 43/61 [00:04<00:02,  8.62it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 349
Number of Robust matches 287



Number of matches 1000
Number of matches After Lowe's Ratio 444
Number of Robust matches 354



Number of matches 1000
Number of matches After Lowe's Ratio 376
Number of Robust matches 296


 77%|███████▋  | 47/61 [00:05<00:01, 10.09it/s]
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 401
Number of Robust matches 302



Number of matches 1000
Number of matches After Lowe's Ratio 358
Number of Robust matches 189



Number of matches 1000
Number of matches After Lowe's Ratio 317
Number of Robust matches 195


 80%|████████  | 49/61 [00:05<00:01, 10.33it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 294
Number of Robust matches 180



Number of matches 1000
Number of matches After Lowe's Ratio 488
Number of Robust matches 411



Number of matches 1000
Number of matches After Lowe's Ratio 453
Number of Robust matches 385


 87%|████████▋ | 53/61 [00:05<00:00, 10.55it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 295
Number of Robust matches 198



Number of matches 1000
Number of matches After Lowe's Ratio 267
Number of Robust matches 179



Number of matches 1000
Number of matches After Lowe's Ratio 369
Number of Robust matches 275


 90%|█████████ | 55/61 [00:05<00:00, 10.73it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 210
Number of Robust matches 153



Number of matches 1000
Number of matches After Lowe's Ratio 239
Number of Robust matches 173



Number of matches 1000
Number of matches After Lowe's Ratio 283
```

Number of matches After Lowe's Ratio 283
Number of Robust matches 192

97%|▉| 59/61 [00:06<00:00, 11.03it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 399
Number of Robust matches 245

Number of matches 1000
Number of matches After Lowe's Ratio 224
Number of Robust matches 102

Number of matches 1000
Number of matches After Lowe's Ratio 351
Number of Robust matches 155

98%|▉| 60/61 [00:06<00:00, 9.66it/s]
5%|▍ | 2/39 [00:00<00:02, 13.20it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 96
Number of Robust matches 28

Number of matches 1000
Number of matches After Lowe's Ratio 375
Number of Robust matches 304

Number of matches 1000
Number of matches After Lowe's Ratio 384
Number of Robust matches 306

10%|▉ | 4/39 [00:00<00:02, 12.14it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 255
Number of Robust matches 200

Number of matches 1000
Number of matches After Lowe's Ratio 102
Number of Robust matches 54

Number of matches 1000
Number of matches After Lowe's Ratio 376
Number of Robust matches 307

21%|▊ | 8/39 [00:00<00:02, 11.57it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 158
Number of Robust matches 113

```
Number of matches 1000
Number of matches After Lowe's Ratio 468
Number of Robust matches 407


Number of matches 1000
Number of matches After Lowe's Ratio 448
Number of Robust matches 386


 26%|██        | 10/39 [00:00<00:02, 11.54it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 398
Number of Robust matches 335


Number of matches 1000
Number of matches After Lowe's Ratio 362
Number of Robust matches 266


Number of matches 1000
Number of matches After Lowe's Ratio 227
Number of Robust matches 143


 36%|███       | 14/39 [00:01<00:02, 11.46it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 352
Number of Robust matches 272


Number of matches 1000
Number of matches After Lowe's Ratio 364
Number of Robust matches 293


Number of matches 1000
Number of matches After Lowe's Ratio 367
Number of Robust matches 278


 41%|████      | 16/39 [00:01<00:01, 11.53it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 304
Number of Robust matches 203


Number of matches 1000
Number of matches After Lowe's Ratio 365
Number of Robust matches 258


Number of matches 1000
Number of matches After Lowe's Ratio 342
Number of Robust matches 223


 51%|█████     | 20/39 [00:01<00:01, 11.64it/s]
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 373
Number of Robust matches 203



Number of matches 1000
Number of matches After Lowe's Ratio 359
Number of Robust matches 212



Number of matches 1000
Number of matches After Lowe's Ratio 263
Number of Robust matches 140


 56%|██████    | 22/39 [00:01<00:01, 11.44it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 210
Number of Robust matches 146



Number of matches 1000
Number of matches After Lowe's Ratio 61
Number of Robust matches 25



Number of matches 1000
Number of matches After Lowe's Ratio 159
Number of Robust matches 92


 62%|██████    | 24/39 [00:02<00:01, 11.03it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 20
Number of Robust matches 5



Number of matches 1000
Number of matches After Lowe's Ratio 125
Number of Robust matches 58



Number of matches 1000
Number of matches After Lowe's Ratio 291
 72%|███████   | 28/39 [00:02<00:00, 11.06it/s]
Number of Robust matches 146



Number of matches 1000
Number of matches After Lowe's Ratio 356
Number of Robust matches 210



Number of matches 1000
Number of matches After Lowe's Ratio 264
Number of Robust matches 120
```

```
 77%|███████▋  | 30/39 [00:02<00:00, 11.00it/s]
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 288
Number of Robust matches 139


Number of matches 1000
Number of matches After Lowe's Ratio 239
Number of Robust matches 78


Number of matches 1000
Number of matches After Lowe's Ratio 391
Number of Robust matches 181
```

```
 87%|████████▋ | 34/39 [00:02<00:00, 11.18it/s]
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 216
Number of Robust matches 123


Number of matches 1000
Number of matches After Lowe's Ratio 82
Number of Robust matches 42


Number of matches 1000
Number of matches After Lowe's Ratio 230
Number of Robust matches 108
```

```
 92%|█████████▏| 36/39 [00:03<00:00, 11.31it/s]
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 170
Number of Robust matches 92


Number of matches 1000
Number of matches After Lowe's Ratio 232
Number of Robust matches 179


Number of matches 1000
Number of matches After Lowe's Ratio 375
Number of Robust matches 332
```

```
 97%|█████████▋| 38/39 [00:03<00:00, 11.35it/s]
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 341
Number of Robust matches 290
```

In [20]:

```
H_left_daisy = []
H_right_daisy = []
```

```
num_matches_daisy = []
num_good_matches_daisy = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_daisy[j:j+2][::-1],points_all_left_daisy[j:j+2][::-1],descriptors_all_left_daisy[j:j+2]
[::-1])
    H_left_daisy.append(H_a)
    num_matches_daisy.append(matches)
    num_good_matches_daisy.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_daisy[j:j+2][::-1],points_all_right_daisy[j:j+2][::-1],descriptors_all_right_daisy[j:
j+2][::-1])
    H_right_daisy.append(H_a)
    num_matches_daisy.append(matches)
    num_good_matches_daisy.append(gd_matches)
```

```
  2%|          | 1/61 [00:03<03:35,  3.59s/it]
Number of matches 15850
Number of matches After Lowe's Ratio 1372
Number of Robust matches 575

  3%|          | 2/61 [00:06<03:25,  3.48s/it]
Number of matches 20463
Number of matches After Lowe's Ratio 844
Number of Robust matches 276

  5%|          | 3/61 [00:11<03:41,  3.83s/it]
Number of matches 16891
Number of matches After Lowe's Ratio 216
Number of Robust matches 11

  7%|          | 4/61 [00:15<03:45,  3.96s/it]
Number of matches 16828
Number of matches After Lowe's Ratio 2669
Number of Robust matches 1471

  8%|          | 5/61 [00:19<03:35,  3.86s/it]
Number of matches 17667
Number of matches After Lowe's Ratio 2256
Number of Robust matches 1313

 10%|          | 6/61 [00:22<03:28,  3.79s/it]
Number of matches 17727
Number of matches After Lowe's Ratio 2538
Number of Robust matches 1309

 11%|          | 7/61 [00:26<03:25,  3.80s/it]
```

11%|▉ | 7/61 [00:26<03:23, 3.63s/it]

```
Number of matches 19250
Number of matches After Lowe's Ratio 2415
Number of Robust matches 1179
```

13%|▉ | 8/61 [00:30<03:20, 3.78s/it]

```
Number of matches 12557
Number of matches After Lowe's Ratio 1065
Number of Robust matches 470
```

15%|▉ | 9/61 [00:32<02:56, 3.40s/it]

```
Number of matches 19090
Number of matches After Lowe's Ratio 1996
Number of Robust matches 1177
```

16%|▉ | 10/61 [00:36<03:01, 3.56s/it]

```
Number of matches 12039
Number of matches After Lowe's Ratio 982
Number of Robust matches 468
```

18%|▉ | 11/61 [00:39<02:43, 3.27s/it]

```
Number of matches 17448
Number of matches After Lowe's Ratio 2364
Number of Robust matches 1269
```

20%|▉ | 12/61 [00:42<02:41, 3.29s/it]

```
Number of matches 15221
Number of matches After Lowe's Ratio 1401
Number of Robust matches 848
```

21%|▉ | 13/61 [00:45<02:37, 3.28s/it]

```
Number of matches 19009
Number of matches After Lowe's Ratio 2302
Number of Robust matches 1536
```

23%|▉ | 14/61 [00:50<02:48, 3.59s/it]

```
Number of matches 18724
Number of matches After Lowe's Ratio 3982
Number of Robust matches 2541
```

25%|▉ | 15/61 [00:54<02:48, 3.67s/it]

```
Number of matches 18161
Number of matches After Lowe's Ratio 3167
Number of Robust matches 2040
```

26%|▉ | 16/61 [00:58<02:48, 3.75s/it]

```
Number of matches 17507
Number of matches After Lowe's Ratio 3090
Number of Robust matches 1976
```

Number of Robust matches 1976

28%|██▊ | 17/61 [01:01<02:43, 3.71s/it]

Number of matches 16984
Number of matches After Lowe's Ratio 2735
Number of Robust matches 1781

30%|██▉ | 18/61 [01:05<02:35, 3.61s/it]

Number of matches 16971
Number of matches After Lowe's Ratio 4022
Number of Robust matches 2518

31%|███ | 19/61 [01:08<02:31, 3.62s/it]

Number of matches 17121
Number of matches After Lowe's Ratio 4302
Number of Robust matches 2860

33%|███▎ | 20/61 [01:12<02:26, 3.57s/it]

Number of matches 17331
Number of matches After Lowe's Ratio 3493
Number of Robust matches 2397

34%|███▍ | 21/61 [01:15<02:22, 3.57s/it]

Number of matches 19219
Number of matches After Lowe's Ratio 2594
Number of Robust matches 1511

36%|███▌ | 22/61 [01:20<02:32, 3.92s/it]

Number of matches 18480
Number of matches After Lowe's Ratio 3544
Number of Robust matches 1727

38%|███▊ | 23/61 [01:24<02:27, 3.88s/it]

Number of matches 19423
Number of matches After Lowe's Ratio 3202
Number of Robust matches 1646

39%|███▉ | 24/61 [01:28<02:25, 3.93s/it]

Number of matches 19540
Number of matches After Lowe's Ratio 3050
Number of Robust matches 1909

41%|████ | 25/61 [01:32<02:24, 4.02s/it]

Number of matches 23070
Number of matches After Lowe's Ratio 506
Number of Robust matches 163

43%|████ | 26/61 [01:37<02:29, 4.27s/it]

```
Number of matches 19327
Number of matches After Lowe's Ratio 1095
Number of Robust matches 545
```

44%|████ | 27/61 [01:41<02:24, 4.25s/it]

```
Number of matches 21616
Number of matches After Lowe's Ratio 2483
Number of Robust matches 1318
```

46%|████ | 28/61 [01:46<02:22, 4.31s/it]

```
Number of matches 19935
Number of matches After Lowe's Ratio 1344
Number of Robust matches 605
```

48%|████ | 29/61 [01:50<02:17, 4.31s/it]

```
Number of matches 22791
Number of matches After Lowe's Ratio 712
Number of Robust matches 282
```

49%|████ | 30/61 [01:56<02:26, 4.72s/it]

```
Number of matches 21497
Number of matches After Lowe's Ratio 2497
Number of Robust matches 1058
```

51%|█████ | 31/61 [02:00<02:22, 4.74s/it]

```
Number of matches 20351
Number of matches After Lowe's Ratio 990
Number of Robust matches 412
```

52%|█████ | 32/61 [02:05<02:16, 4.71s/it]

```
Number of matches 17412
Number of matches After Lowe's Ratio 261
Number of Robust matches 23
```

54%|█████ | 33/61 [02:09<02:03, 4.42s/it]

```
Number of matches 16896
Number of matches After Lowe's Ratio 2470
Number of Robust matches 1086
```

56%|█████ | 34/61 [02:12<01:51, 4.13s/it]

```
Number of matches 16303
Number of matches After Lowe's Ratio 3038
Number of Robust matches 1654
```

57%|█████ | 35/61 [02:16<01:43, 3.99s/it]

```
Number of matches 18249
Number of matches After Lowe's Ratio 2430
```

```
Number of Robust matches 1306

 59%|█████▉    | 36/61 [02:20<01:40,  4.02s/it]

Number of matches 21853
Number of matches After Lowe's Ratio 3492
Number of Robust matches 1773

 61%|██████    | 37/61 [02:25<01:46,  4.45s/it]

Number of matches 24851
Number of matches After Lowe's Ratio 3110
Number of Robust matches 1158

 62%|██████    | 38/61 [02:31<01:50,  4.79s/it]

Number of matches 28347
Number of matches After Lowe's Ratio 3923
Number of Robust matches 1380

 64%|██████    | 39/61 [02:38<01:57,  5.32s/it]

Number of matches 24822
Number of matches After Lowe's Ratio 3251
Number of Robust matches 1343

 66%|██████    | 40/61 [02:43<01:52,  5.34s/it]

Number of matches 20000
Number of matches After Lowe's Ratio 3242
Number of Robust matches 1725

 67%|██████    | 41/61 [02:47<01:40,  5.04s/it]

Number of matches 18074
Number of matches After Lowe's Ratio 3729
Number of Robust matches 2216

 69%|██████    | 42/61 [02:51<01:27,  4.59s/it]

Number of matches 16132
Number of matches After Lowe's Ratio 3446
Number of Robust matches 2369

 70%|███████   | 43/61 [02:54<01:15,  4.21s/it]

Number of matches 16505
Number of matches After Lowe's Ratio 4387
Number of Robust matches 2969

 72%|███████   | 44/61 [02:58<01:11,  4.19s/it]

Number of matches 17795
Number of matches After Lowe's Ratio 3611
Number of Robust matches 2478
```

74%|███████▍ | 45/61 [03:02<01:04, 4.03s/it]

```
Number of matches 19052
Number of matches After Lowe's Ratio 4046
Number of Robust matches 2344
```

75%|███████▌ | 46/61 [03:06<01:00, 4.00s/it]

```
Number of matches 18726
Number of matches After Lowe's Ratio 4822
Number of Robust matches 2609
```

77%|███████▋ | 47/61 [03:10<00:56, 4.00s/it]

```
Number of matches 18580
Number of matches After Lowe's Ratio 4372
Number of Robust matches 2437
```

79%|███████▊ | 48/61 [03:13<00:50, 3.89s/it]

```
Number of matches 15741
Number of matches After Lowe's Ratio 2441
Number of Robust matches 1518
```

80%|███████▉ | 49/61 [03:17<00:44, 3.69s/it]

```
Number of matches 14586
Number of matches After Lowe's Ratio 4232
Number of Robust matches 2963
```

82%|████████▏ | 50/61 [03:20<00:38, 3.52s/it]

```
Number of matches 16381
Number of matches After Lowe's Ratio 3903
Number of Robust matches 2815
```

84%|████████▎ | 51/61 [03:23<00:34, 3.41s/it]

```
Number of matches 15190
Number of matches After Lowe's Ratio 2527
Number of Robust matches 1659
```

85%|████████▌ | 52/61 [03:26<00:29, 3.28s/it]

```
Number of matches 16204
Number of matches After Lowe's Ratio 2981
Number of Robust matches 1890
```

87%|████████▋ | 53/61 [03:30<00:27, 3.47s/it]

```
Number of matches 16360
Number of matches After Lowe's Ratio 4024
Number of Robust matches 2843
```

89%|████████▊ | 54/61 [03:33<00:23, 3.42s/it]

```
Number of matches 16749
Number of matches After Lowe's Ratio 2522
```

Number of Robust matches 1479

90%|▉ | 55/61 [03:36<00:20, 3.39s/it]

Number of matches 16958
Number of matches After Lowe's Ratio 2932
Number of Robust matches 1900

92%|▉ | 56/61 [03:40<00:16, 3.38s/it]

Number of matches 16883
Number of matches After Lowe's Ratio 2379
Number of Robust matches 1471

93%|▉ | 57/61 [03:43<00:13, 3.45s/it]

Number of matches 16697
Number of matches After Lowe's Ratio 4004
Number of Robust matches 2085

95%|▉ | 58/61 [03:47<00:10, 3.40s/it]

Number of matches 17245
Number of matches After Lowe's Ratio 1926
Number of Robust matches 806

97%|▉ | 59/61 [03:50<00:06, 3.41s/it]

Number of matches 16937
Number of matches After Lowe's Ratio 3028
Number of Robust matches 1310

98%|▉| 60/61 [03:54<00:03, 3.90s/it]
0%| | 0/39 [00:00<?, ?it/s]

Number of matches 14790
Number of matches After Lowe's Ratio 750
Number of Robust matches 212

3%|▏ | 1/39 [00:03<02:29, 3.94s/it]

Number of matches 20488
Number of matches After Lowe's Ratio 3319
Number of Robust matches 1857

5%|▏ | 2/39 [00:08<02:38, 4.28s/it]

Number of matches 14865
Number of matches After Lowe's Ratio 2264
Number of Robust matches 1518

8%|▏ | 3/39 [00:11<02:13, 3.71s/it]

Number of matches 10652
Number of matches After Lowe's Ratio 953
Number of Robust matches 586

```
 10%|▉         | 4/39 [00:13<01:46,  3.04s/it]
Number of matches 14443
Number of matches After Lowe's Ratio 720
Number of Robust matches 286

 13%|▉         | 5/39 [00:16<01:38,  2.91s/it]
Number of matches 10456
Number of matches After Lowe's Ratio 1574
Number of Robust matches 906

 15%|▉         | 6/39 [00:18<01:27,  2.64s/it]
Number of matches 17715
Number of matches After Lowe's Ratio 944
Number of Robust matches 529

 18%|▉         | 7/39 [00:22<01:38,  3.09s/it]
Number of matches 18284
Number of matches After Lowe's Ratio 4575
Number of Robust matches 3397

 21%|▉         | 8/39 [00:26<01:41,  3.29s/it]
Number of matches 17764
Number of matches After Lowe's Ratio 4646
Number of Robust matches 3348

 23%|▉         | 9/39 [00:29<01:41,  3.38s/it]
Number of matches 17499
Number of matches After Lowe's Ratio 3410
Number of Robust matches 2243

 26%|▉         | 10/39 [00:33<01:42,  3.53s/it]
Number of matches 19138
Number of matches After Lowe's Ratio 3412
Number of Robust matches 2531

 28%|▉         | 11/39 [00:37<01:43,  3.70s/it]
Number of matches 21978
Number of matches After Lowe's Ratio 2204
Number of Robust matches 1435

 31%|▉         | 12/39 [00:43<01:54,  4.26s/it]
Number of matches 23315
Number of matches After Lowe's Ratio 3932
Number of Robust matches 2208

 33%|▉         | 13/39 [00:48<01:57,  4.50s/it]
```

```
Number of matches 25930
Number of matches After Lowe's Ratio 3903
Number of Robust matches 2129
```

```
 36%|███       | 14/39 [00:54<02:04,  4.97s/it]
```

```
Number of matches 25725
Number of matches After Lowe's Ratio 4092
Number of Robust matches 2146
```

```
 38%|███       | 15/39 [00:59<02:04,  5.21s/it]
```

```
Number of matches 25272
Number of matches After Lowe's Ratio 3572
Number of Robust matches 1815
```

```
 41%|████      | 16/39 [01:05<02:02,  5.33s/it]
```

```
Number of matches 23716
Number of matches After Lowe's Ratio 4363
Number of Robust matches 2015
```

```
 44%|████      | 17/39 [01:10<01:56,  5.28s/it]
```

```
Number of matches 21541
Number of matches After Lowe's Ratio 3068
Number of Robust matches 1178
```

```
 46%|████      | 18/39 [01:15<01:48,  5.18s/it]
```

```
Number of matches 20126
Number of matches After Lowe's Ratio 4465
Number of Robust matches 1943
```

```
 49%|████      | 19/39 [01:19<01:37,  4.85s/it]
```

```
Number of matches 18854
Number of matches After Lowe's Ratio 3739
Number of Robust matches 1656
```

```
 51%|█████     | 20/39 [01:23<01:27,  4.59s/it]
```

```
Number of matches 17303
Number of matches After Lowe's Ratio 2755
Number of Robust matches 1053
```

```
 54%|█████     | 21/39 [01:27<01:18,  4.34s/it]
```

```
Number of matches 18642
Number of matches After Lowe's Ratio 2339
Number of Robust matches 1040
```

```
 56%|█████     | 22/39 [01:31<01:13,  4.30s/it]
```

```
Number of matches 27086
Number of matches After Lowe's Ratio 581
Number of Robust matches 149
```

59%|▉▉▉▉▉▉ | 23/39 [01:37<01:17, 4.85s/it]

```
Number of matches 22491
Number of matches After Lowe's Ratio 1561
Number of Robust matches 628
```

62%|▉▉▉▉▉▉ | 24/39 [01:43<01:16, 5.09s/it]

```
Number of matches 31012
Number of matches After Lowe's Ratio 312
Number of Robust matches 11
```

64%|▉▉▉▉▉▉ | 25/39 [01:50<01:18, 5.63s/it]

```
Number of matches 24213
Number of matches After Lowe's Ratio 850
Number of Robust matches 296
```

67%|▉▉▉▉▉▉ | 26/39 [01:55<01:11, 5.49s/it]

```
Number of matches 22667
Number of matches After Lowe's Ratio 3760
Number of Robust matches 1704
```

69%|▉▉▉▉▉▉ | 27/39 [02:00<01:04, 5.34s/it]

```
Number of matches 19376
Number of matches After Lowe's Ratio 2905
Number of Robust matches 1177
```

72%|▉▉▉▉▉▉▉ | 28/39 [02:04<00:54, 4.98s/it]

```
Number of matches 18221
Number of matches After Lowe's Ratio 2081
Number of Robust matches 784
```

74%|▉▉▉▉▉▉▉ | 29/39 [02:08<00:46, 4.61s/it]

```
Number of matches 19609
Number of matches After Lowe's Ratio 2230
Number of Robust matches 847
```

77%|▉▉▉▉▉▉▉ | 30/39 [02:12<00:40, 4.50s/it]

```
Number of matches 19236
Number of matches After Lowe's Ratio 2166
Number of Robust matches 798
```

79%|▉▉▉▉▉▉▉ | 31/39 [02:17<00:35, 4.48s/it]

```
Number of matches 18754
Number of matches After Lowe's Ratio 4379
Number of Robust matches 1662
```

82%|▉▉▉▉▉▉▉▉ | 32/39 [02:21<00:30, 4.40s/it]

```
Number of matches 20522
Number of matches After Lowe's Ratio 2026
Number of Robust matches 746
```

```
 85%|████████  | 33/39 [02:25<00:26,  4.34s/it]
```

```
Number of matches 20368
Number of matches After Lowe's Ratio 2014
Number of Robust matches 1024
```

```
 87%|████████  | 34/39 [02:29<00:21,  4.32s/it]
```

```
Number of matches 19692
Number of matches After Lowe's Ratio 2937
Number of Robust matches 1539
```

```
 90%|████████  | 35/39 [02:34<00:17,  4.33s/it]
```

```
Number of matches 17996
Number of matches After Lowe's Ratio 2212
Number of Robust matches 1267
```

```
 92%|████████  | 36/39 [02:37<00:12,  4.13s/it]
```

```
Number of matches 17038
Number of matches After Lowe's Ratio 1655
Number of Robust matches 1187
```

```
 95%|████████  | 37/39 [02:41<00:07,  3.97s/it]
```

```
Number of matches 17238
Number of matches After Lowe's Ratio 2251
Number of Robust matches 1502
```

```
 97%|████████  | 38/39 [02:45<00:04,  4.35s/it]
```

```
Number of matches 16004
Number of matches After Lowe's Ratio 2159
Number of Robust matches 1260
```

In [ ]:

```
H_left_fast = []
H_right_fast = []

num_matches_fast = []
num_good_matches_fast = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_fast[j:j+2][::-1],points_all_left_fast[j:j+2][::-1],descriptors_all_left_fast[j:j+2][::
-1])
    H_left_fast.append(H_a)
    num_matches_fast.append(matches)
    num_good_matches_fast.append(gd_matches)
```

```
for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_fast[j:j+2][::-1],points_all_right_fast[j:j+2][::-1],descriptors_all_right_fast[j:j+2
][::-1])
    H_right_fast.append(H_a)
    num_matches_fast.append(matches)
    num_good_matches_fast.append(gd_matches)
```

In [ ]:

```
H_left_star = []
H_right_star = []

num_matches_star = []
num_good_matches_star = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_star[j:j+2][::-1],points_all_left_star[j:j+2][::-1],descriptors_all_left_brief[j:j+2][:
:-1])
    H_left_star.append(H_a)
    num_matches_star.append(matches)
    num_good_matches_star.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_star[j:j+2][::-1],points_all_right_star[j:j+2][::-1],descriptors_all_right_brief[j:j+
2][::-1])
    H_right_star.append(H_a)
    num_matches_star.append(matches)
    num_good_matches_star.append(gd_matches)
```

In [20]:

```
H_left_sift = []
H_right_sift = []

num_matches_sift = []
num_good_matches_sift = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_sift[j:j+2][::-1],points_all_left_sift[j:j+2][::-1],descriptors_all_left_sift[j:j+2][::
-1])
    H_left_sift.append(H_a)
    num_matches_sift.append(matches)
    num_good_matches_sift.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_sift[j:j+2][::-1],points_all_right_sift[j:j+2][::-1],descriptors_all_right_sift[j:j+2
][::-1])
    H_right_sift.append(H_a)
    num_matches_sift.append(matches)
    num_good_matches_sift.append(gd_matches)
```

```
  2%|▏          | 1/61 [00:02<02:34,  2.58s/it]
```

```
Number of matches 15850
Number of matches After Lowe's Ratio 1864
Number of Robust matches 892


  3%|▎         | 2/61 [00:04<02:15,  2.30s/it]
Number of matches 20463
Number of matches After Lowe's Ratio 1435
Number of Robust matches 712


  5%|▍         | 3/61 [00:07<02:30,  2.59s/it]
Number of matches 16891
Number of matches After Lowe's Ratio 697
Number of Robust matches 172


  7%|▋         | 4/61 [00:09<02:21,  2.48s/it]
Number of matches 16828
Number of matches After Lowe's Ratio 2801
Number of Robust matches 1635


  8%|▊         | 5/61 [00:12<02:15,  2.41s/it]
Number of matches 17667
Number of matches After Lowe's Ratio 3395
Number of Robust matches 2070


 10%|▉         | 6/61 [00:14<02:11,  2.39s/it]
Number of matches 17727
Number of matches After Lowe's Ratio 3207
Number of Robust matches 1808


 11%|█         | 7/61 [00:17<02:13,  2.47s/it]
Number of matches 19250
Number of matches After Lowe's Ratio 3560
Number of Robust matches 1984


 13%|█▏        | 8/61 [00:19<02:10,  2.47s/it]
Number of matches 12557
Number of matches After Lowe's Ratio 1724
Number of Robust matches 887


 15%|█▍        | 9/61 [00:21<01:55,  2.21s/it]
Number of matches 19090
Number of matches After Lowe's Ratio 2797
Number of Robust matches 1544


 16%|█▋        | 10/61 [00:23<01:58,  2.32s/it]
Number of matches 12039
Number of matches After Lowe's Ratio 1394
Number of Robust matches 741
```

Number of Robust matches 711

18%|▉ | 11/61 [00:25<01:44, 2.09s/it]

Number of matches 17448
Number of matches After Lowe's Ratio 2907
Number of Robust matches 1765

20%|▉ | 12/61 [00:27<01:48, 2.21s/it]

Number of matches 15221
Number of matches After Lowe's Ratio 3061
Number of Robust matches 2079

21%|▉ | 13/61 [00:29<01:43, 2.15s/it]

Number of matches 19009
Number of matches After Lowe's Ratio 3166
Number of Robust matches 2158

23%|▉ | 14/61 [00:32<01:46, 2.26s/it]

Number of matches 18724
Number of matches After Lowe's Ratio 4531
Number of Robust matches 3215

25%|▉ | 15/61 [00:35<01:55, 2.50s/it]

Number of matches 18161
Number of matches After Lowe's Ratio 3394
Number of Robust matches 2230

26%|▉ | 16/61 [00:37<01:51, 2.48s/it]

Number of matches 17507
Number of matches After Lowe's Ratio 3743
Number of Robust matches 2647

28%|▉ | 17/61 [00:40<01:50, 2.51s/it]

Number of matches 16984
Number of matches After Lowe's Ratio 3363
Number of Robust matches 2469

30%|▉ | 18/61 [00:42<01:44, 2.43s/it]

Number of matches 16971
Number of matches After Lowe's Ratio 4068
Number of Robust matches 3247

31%|▉ | 19/61 [00:45<01:40, 2.40s/it]

Number of matches 17121
Number of matches After Lowe's Ratio 4417
Number of Robust matches 3504

33%|▉ | 20/61 [00:47<01:36, 2.35s/it]

33%|███ | 20/61 [00:47<01:36, 2.35s/it]

```
Number of matches 17331
Number of matches After Lowe's Ratio 3651
Number of Robust matches 2519
```

34%|███ | 21/61 [00:49<01:35, 2.39s/it]

```
Number of matches 19219
Number of matches After Lowe's Ratio 3274
Number of Robust matches 2150
```

36%|███ | 22/61 [00:52<01:34, 2.42s/it]

```
Number of matches 18480
Number of matches After Lowe's Ratio 3262
Number of Robust matches 2034
```

38%|███ | 23/61 [00:54<01:32, 2.43s/it]

```
Number of matches 19423
Number of matches After Lowe's Ratio 3582
Number of Robust matches 2271
```

39%|███ | 24/61 [00:57<01:33, 2.52s/it]

```
Number of matches 19540
Number of matches After Lowe's Ratio 2866
Number of Robust matches 1800
```

41%|███ | 25/61 [01:00<01:32, 2.57s/it]

```
Number of matches 23070
Number of matches After Lowe's Ratio 2609
Number of Robust matches 1459
```

43%|███ | 26/61 [01:03<01:37, 2.80s/it]

```
Number of matches 19327
Number of matches After Lowe's Ratio 2826
Number of Robust matches 1529
```

44%|███ | 27/61 [01:06<01:38, 2.90s/it]

```
Number of matches 21616
Number of matches After Lowe's Ratio 2746
Number of Robust matches 1306
```

46%|███ | 28/61 [01:09<01:36, 2.91s/it]

```
Number of matches 19935
Number of matches After Lowe's Ratio 2837
Number of Robust matches 1185
```

48%|███ | 29/61 [01:12<01:34, 2.96s/it]

```
Number of matches 22791
Number of matches After Lowe's Ratio 1860
```

```
Number of Robust matches 776

 49%|████▉     | 30/61 [01:15<01:33,  3.00s/it]

Number of matches 21497
Number of matches After Lowe's Ratio 2687
Number of Robust matches 1361

 51%|█████     | 31/61 [01:18<01:28,  2.96s/it]

Number of matches 20351
Number of matches After Lowe's Ratio 1339
Number of Robust matches 615

 52%|█████▏    | 32/61 [01:21<01:22,  2.86s/it]

Number of matches 17412
Number of matches After Lowe's Ratio 896
Number of Robust matches 262

 54%|█████▍    | 33/61 [01:23<01:17,  2.76s/it]

Number of matches 16896
Number of matches After Lowe's Ratio 2277
Number of Robust matches 1241

 56%|█████▌    | 34/61 [01:26<01:10,  2.62s/it]

Number of matches 16303
Number of matches After Lowe's Ratio 2567
Number of Robust matches 1454

 57%|█████▋    | 35/61 [01:28<01:04,  2.46s/it]

Number of matches 18249
Number of matches After Lowe's Ratio 2275
Number of Robust matches 1350

 59%|█████▉    | 36/61 [01:30<01:01,  2.48s/it]

Number of matches 21853
Number of matches After Lowe's Ratio 3067
Number of Robust matches 1671

 61%|██████    | 37/61 [01:33<01:05,  2.72s/it]

Number of matches 24851
Number of matches After Lowe's Ratio 2895
Number of Robust matches 1182

 62%|██████▏   | 38/61 [01:38<01:13,  3.18s/it]

Number of matches 28347
Number of matches After Lowe's Ratio 3294
Number of Robust matches 1059
```

64%|██████ | 39/61 [01:42<01:16, 3.48s/it]

```
Number of matches 24822
Number of matches After Lowe's Ratio 3179
Number of Robust matches 1382
```

66%|██████ | 40/61 [01:46<01:14, 3.55s/it]

```
Number of matches 20000
Number of matches After Lowe's Ratio 3161
Number of Robust matches 1584
```

67%|██████▌ | 41/61 [01:48<01:05, 3.27s/it]

```
Number of matches 18074
Number of matches After Lowe's Ratio 3253
Number of Robust matches 2142
```

69%|██████▊ | 42/61 [01:51<00:56, 2.98s/it]

```
Number of matches 16132
Number of matches After Lowe's Ratio 3391
Number of Robust matches 2511
```

70%|██████▉ | 43/61 [01:53<00:49, 2.74s/it]

```
Number of matches 16505
Number of matches After Lowe's Ratio 3763
Number of Robust matches 2852
```

72%|███████ | 44/61 [01:55<00:43, 2.59s/it]

```
Number of matches 17795
Number of matches After Lowe's Ratio 3435
Number of Robust matches 2225
```

74%|███████▏ | 45/61 [01:57<00:40, 2.55s/it]

```
Number of matches 19052
Number of matches After Lowe's Ratio 3828
Number of Robust matches 2412
```

75%|███████▌ | 46/61 [02:00<00:38, 2.54s/it]

```
Number of matches 18726
Number of matches After Lowe's Ratio 4342
Number of Robust matches 2446
```

77%|███████▋ | 47/61 [02:02<00:35, 2.51s/it]

```
Number of matches 18580
Number of matches After Lowe's Ratio 4333
Number of Robust matches 2512
```

79%|███████▊ | 48/61 [02:05<00:33, 2.54s/it]

```
Number of matches 15741
Number of matches After Lowe's Ratio 2711
```

```
Number of Robust matches 1737

 80%|████████  | 49/61 [02:07<00:29,  2.45s/it]

Number of matches 14586
Number of matches After Lowe's Ratio 4071
Number of Robust matches 2825

 82%|████████  | 50/61 [02:09<00:26,  2.39s/it]

Number of matches 16381
Number of matches After Lowe's Ratio 3888
Number of Robust matches 2909

 84%|████████  | 51/61 [02:12<00:23,  2.32s/it]

Number of matches 15190
Number of matches After Lowe's Ratio 2709
Number of Robust matches 1888

 85%|████████  | 52/61 [02:14<00:19,  2.21s/it]

Number of matches 16204
Number of matches After Lowe's Ratio 2869
Number of Robust matches 1898

 87%|████████  | 53/61 [02:16<00:17,  2.17s/it]

Number of matches 16360
Number of matches After Lowe's Ratio 3616
Number of Robust matches 2402

 89%|████████  | 54/61 [02:18<00:15,  2.27s/it]

Number of matches 16749
Number of matches After Lowe's Ratio 2995
Number of Robust matches 1898

 90%|████████  | 55/61 [02:20<00:13,  2.24s/it]

Number of matches 16958
Number of matches After Lowe's Ratio 3333
Number of Robust matches 2217

 92%|████████  | 56/61 [02:22<00:11,  2.23s/it]

Number of matches 16883
Number of matches After Lowe's Ratio 2961
Number of Robust matches 1742

 93%|████████  | 57/61 [02:25<00:08,  2.22s/it]

Number of matches 16697
Number of matches After Lowe's Ratio 4111
Number of Robust matches 2299
```

```
 95%|█████████ | 58/61 [02:27<00:06,  2.25s/it]

Number of matches 17245
Number of matches After Lowe's Ratio 2551
Number of Robust matches 986


 97%|█████████ | 59/61 [02:29<00:04,  2.30s/it]

Number of matches 16937
Number of matches After Lowe's Ratio 3643
Number of Robust matches 1638


 98%|█████████ | 60/61 [02:32<00:02,  2.53s/it]
  0%|          | 0/39 [00:00<?, ?it/s]

Number of matches 14790
Number of matches After Lowe's Ratio 1408
Number of Robust matches 515


  3%|▎         | 1/39 [00:02<01:29,  2.36s/it]

Number of matches 20488
Number of matches After Lowe's Ratio 2892
Number of Robust matches 2014


  5%|▌         | 2/39 [00:05<01:34,  2.56s/it]

Number of matches 14865
Number of matches After Lowe's Ratio 2617
Number of Robust matches 1777


  8%|▊         | 3/39 [00:06<01:19,  2.21s/it]

Number of matches 10652
Number of matches After Lowe's Ratio 1414
Number of Robust matches 774


 10%|█         | 4/39 [00:08<01:08,  1.97s/it]

Number of matches 14443
Number of matches After Lowe's Ratio 1079
Number of Robust matches 500


 13%|█▎        | 5/39 [00:10<01:12,  2.12s/it]

Number of matches 10456
Number of matches After Lowe's Ratio 2226
Number of Robust matches 1556


 15%|█▌        | 6/39 [00:12<01:01,  1.87s/it]

Number of matches 17715
Number of matches After Lowe's Ratio 1476
Number of Robust matches 823


 18%|█▊        | 7/39 [00:14<01:04,  2.01s/it]

Number of matches 18284
```

Number of matches 18284
Number of matches After Lowe's Ratio 4231
Number of Robust matches 3455

21%|██ | 8/39 [00:16<01:06, 2.13s/it]

Number of matches 17764
Number of matches After Lowe's Ratio 4330
Number of Robust matches 3603

23%|██ | 9/39 [00:19<01:08, 2.27s/it]

Number of matches 17499
Number of matches After Lowe's Ratio 3679
Number of Robust matches 2707

26%|██ | 10/39 [00:21<01:07, 2.34s/it]

Number of matches 19138
Number of matches After Lowe's Ratio 3607
Number of Robust matches 2876

28%|██ | 11/39 [00:24<01:08, 2.44s/it]

Number of matches 21978
Number of matches After Lowe's Ratio 2784
Number of Robust matches 1918

31%|███ | 12/39 [00:27<01:10, 2.61s/it]

Number of matches 23315
Number of matches After Lowe's Ratio 3697
Number of Robust matches 2449

33%|███ | 13/39 [00:31<01:16, 2.95s/it]

Number of matches 25930
Number of matches After Lowe's Ratio 3576
Number of Robust matches 1805

36%|███ | 14/39 [00:35<01:21, 3.25s/it]

Number of matches 25725
Number of matches After Lowe's Ratio 4168
Number of Robust matches 2311

38%|███ | 15/39 [00:39<01:22, 3.43s/it]

Number of matches 25272
Number of matches After Lowe's Ratio 4208
Number of Robust matches 2200

41%|████ | 16/39 [00:43<01:25, 3.74s/it]

Number of matches 23716
Number of matches After Lowe's Ratio 4351
Number of Robust matches 2116

```
 44%|████      | 17/39 [00:46<01:19,  3.62s/it]
Number of matches 21541
Number of matches After Lowe's Ratio 3408
Number of Robust matches 1461

 46%|████      | 18/39 [00:50<01:12,  3.45s/it]
Number of matches 20126
Number of matches After Lowe's Ratio 4068
Number of Robust matches 1643

 49%|████      | 19/39 [00:52<01:05,  3.30s/it]
Number of matches 18854
Number of matches After Lowe's Ratio 3323
Number of Robust matches 1300

 51%|█████     | 20/39 [00:55<00:57,  3.05s/it]
Number of matches 17303
Number of matches After Lowe's Ratio 3032
Number of Robust matches 1194

 54%|█████     | 21/39 [00:57<00:50,  2.82s/it]
Number of matches 18642
Number of matches After Lowe's Ratio 2548
Number of Robust matches 1319

 56%|█████     | 22/39 [01:00<00:47,  2.80s/it]
Number of matches 27086
Number of matches After Lowe's Ratio 1038
Number of Robust matches 339

 59%|█████     | 23/39 [01:04<00:51,  3.19s/it]
Number of matches 22491
Number of matches After Lowe's Ratio 1640
Number of Robust matches 620

 62%|██████    | 24/39 [01:07<00:48,  3.22s/it]
Number of matches 31012
Number of matches After Lowe's Ratio 462
Number of Robust matches 16

 64%|██████    | 25/39 [01:12<00:50,  3.62s/it]
Number of matches 24213
Number of matches After Lowe's Ratio 1761
Number of Robust matches 547

 67%|██████    | 26/39 [01:16<00:49,  3.82s/it]
```

```
Number of matches 22667
Number of matches After Lowe's Ratio 3463
Number of Robust matches 1378


 69%|██████    | 27/39 [01:19<00:42,  3.58s/it]

Number of matches 19376
Number of matches After Lowe's Ratio 2847
Number of Robust matches 1198


 72%|███████   | 28/39 [01:22<00:35,  3.27s/it]

Number of matches 18221
Number of matches After Lowe's Ratio 2552
Number of Robust matches 1075


 74%|███████   | 29/39 [01:24<00:30,  3.10s/it]

Number of matches 19609
Number of matches After Lowe's Ratio 2844
Number of Robust matches 1014


 77%|███████   | 30/39 [01:27<00:26,  2.96s/it]

Number of matches 19236
Number of matches After Lowe's Ratio 2759
Number of Robust matches 1007


 79%|███████   | 31/39 [01:30<00:23,  2.89s/it]

Number of matches 18754
Number of matches After Lowe's Ratio 4215
Number of Robust matches 1741


 82%|████████  | 32/39 [01:32<00:19,  2.78s/it]

Number of matches 20522
Number of matches After Lowe's Ratio 2723
Number of Robust matches 970


 85%|████████  | 33/39 [01:35<00:17,  2.84s/it]

Number of matches 20368
Number of matches After Lowe's Ratio 4223
Number of Robust matches 2254


 87%|████████  | 34/39 [01:38<00:14,  2.82s/it]

Number of matches 19692
Number of matches After Lowe's Ratio 3259
Number of Robust matches 1402


 90%|████████  | 35/39 [01:41<00:10,  2.75s/it]

Number of matches 17996
Number of matches After Lowe's Ratio 2541
Number of Robust matches 1248
```

```
 92%|█████████ | 36/39 [01:43<00:08,  2.67s/it]
```

```
Number of matches 17038
Number of matches After Lowe's Ratio 2137
Number of Robust matches 1580
```

```
 95%|█████████ | 37/39 [01:45<00:05,  2.56s/it]
```

```
Number of matches 17238
Number of matches After Lowe's Ratio 2607
Number of Robust matches 1840
```

```
 97%|█████████ | 38/39 [01:48<00:02,  2.86s/it]
```

```
Number of matches 16004
Number of matches After Lowe's Ratio 2311
Number of Robust matches 1432
```

In [29]:

```
H_left_surf = []
H_right_surf = []

num_matches_surf = []
num_good_matches_surf = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_surf[j:j+2][::-1],points_all_left_surf[j:j++2][::-1],descriptors_all_left_surf[j:j+2][:
:-1])
    H_left_surf.append(H_a)
    num_matches_surf.append(matches)
    num_good_matches_surf.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_surf[j:j+2][::-1],points_all_right_surf[j:j+2][::-1],descriptors_all_right_surf[j:j+2
][::-1])
    H_right_surf.append(H_a)
    num_matches_surf.append(matches)
    num_good_matches_surf.append(gd_matches)
```

```
  2%|          | 1/61 [00:04<04:27,  4.45s/it]
```

```
Number of matches 41423
Number of matches After Lowe's Ratio 3117
Number of Robust matches 1175
```

```
  3%|          | 2/61 [00:08<04:02,  4.11s/it]
```

```
Number of matches 41128
Number of matches After Lowe's Ratio 2172
Number of Robust matches 694
```

```
  5%|          | 3/61 [00:12<03:51,  4.00s/it]
```

```
Number of matches 39642
Number of matches After Lowe's Ratio 1267
Number of Robust matches 16


  7%|▋         | 4/61 [00:15<03:41,  3.89s/it]
Number of matches 42974
Number of matches After Lowe's Ratio 5628
Number of Robust matches 2759


  8%|▊         | 5/61 [00:19<03:37,  3.88s/it]
Number of matches 39256
Number of matches After Lowe's Ratio 4121
Number of Robust matches 1843


 10%|▉         | 6/61 [00:23<03:27,  3.78s/it]
Number of matches 38139
Number of matches After Lowe's Ratio 4128
Number of Robust matches 1796


 11%|█         | 7/61 [00:26<03:20,  3.71s/it]
Number of matches 39467
Number of matches After Lowe's Ratio 4291
Number of Robust matches 1985


 13%|█▏        | 8/61 [00:30<03:14,  3.66s/it]
Number of matches 36010
Number of matches After Lowe's Ratio 3377
Number of Robust matches 1588


 15%|█▎        | 9/61 [00:33<03:06,  3.58s/it]
Number of matches 38370
Number of matches After Lowe's Ratio 3819
Number of Robust matches 1800


 16%|█▍        | 10/61 [00:37<03:01,  3.56s/it]
Number of matches 32669
Number of matches After Lowe's Ratio 2956
Number of Robust matches 1124


 18%|█▌        | 11/61 [00:40<02:48,  3.38s/it]
Number of matches 34564
Number of matches After Lowe's Ratio 4354
Number of Robust matches 2225


 20%|█▋        | 12/61 [00:43<02:38,  3.23s/it]
Number of matches 34700
Number of matches After Lowe's Ratio 3902
Number of Robust matches 1969
```

Number of Robust matches 1909

21%|██ | 13/61 [00:46<02:34, 3.21s/it]

Number of matches 37406
Number of matches After Lowe's Ratio 4545
Number of Robust matches 1945

23%|██ | 14/61 [00:49<02:35, 3.31s/it]

Number of matches 38907
Number of matches After Lowe's Ratio 6843
Number of Robust matches 4486

25%|██ | 15/61 [00:53<02:35, 3.39s/it]

Number of matches 37650
Number of matches After Lowe's Ratio 6050
Number of Robust matches 3740

26%|██ | 16/61 [00:56<02:30, 3.36s/it]

Number of matches 38049
Number of matches After Lowe's Ratio 6076
Number of Robust matches 3623

28%|██ | 17/61 [01:00<02:32, 3.47s/it]

Number of matches 38270
Number of matches After Lowe's Ratio 5944
Number of Robust matches 4132

30%|██ | 18/61 [01:03<02:27, 3.43s/it]

Number of matches 38222
Number of matches After Lowe's Ratio 6875
Number of Robust matches 4845

31%|███ | 19/61 [01:07<02:31, 3.61s/it]

Number of matches 37766
Number of matches After Lowe's Ratio 7589
Number of Robust matches 5408

33%|███ | 20/61 [01:11<02:27, 3.59s/it]

Number of matches 38678
Number of matches After Lowe's Ratio 5996
Number of Robust matches 4047

34%|███ | 21/61 [01:15<02:23, 3.58s/it]

Number of matches 38137
Number of matches After Lowe's Ratio 4759
Number of Robust matches 2834

36%|███ | 22/61 [01:18<02:16, 3.50s/it]

36%|███ | 22/61 [01:18<02:16, 3.50s/it]

```
Number of matches 37525
Number of matches After Lowe's Ratio 5417
Number of Robust matches 3476
```

38%|███ | 23/61 [01:21<02:13, 3.51s/it]

```
Number of matches 37759
Number of matches After Lowe's Ratio 4422
Number of Robust matches 2530
```

39%|███ | 24/61 [01:25<02:07, 3.45s/it]

```
Number of matches 38066
Number of matches After Lowe's Ratio 4906
Number of Robust matches 2808
```

41%|███ | 25/61 [01:28<02:02, 3.41s/it]

```
Number of matches 38808
Number of matches After Lowe's Ratio 2660
Number of Robust matches 987
```

43%|███ | 26/61 [01:32<02:00, 3.45s/it]

```
Number of matches 37519
Number of matches After Lowe's Ratio 2982
Number of Robust matches 1152
```

44%|███ | 27/61 [01:35<01:57, 3.46s/it]

```
Number of matches 35706
Number of matches After Lowe's Ratio 3921
Number of Robust matches 1859
```

46%|███ | 28/61 [01:38<01:53, 3.45s/it]

```
Number of matches 39467
Number of matches After Lowe's Ratio 3341
Number of Robust matches 1071
```

48%|███ | 29/61 [01:42<01:54, 3.58s/it]

```
Number of matches 36038
Number of matches After Lowe's Ratio 2086
Number of Robust matches 664
```

49%|███ | 30/61 [01:46<01:51, 3.60s/it]

```
Number of matches 37306
Number of matches After Lowe's Ratio 3302
Number of Robust matches 1468
```

51%|███ | 31/61 [01:49<01:46, 3.54s/it]

```
Number of matches 35977
Number of matches After Lowe's Ratio 1921
```

```
Number of Robust matches 661

 52%|█████     | 32/61 [01:53<01:39,  3.42s/it]

Number of matches 35736
Number of matches After Lowe's Ratio 1525
Number of Robust matches 253

 54%|█████     | 33/61 [01:56<01:37,  3.47s/it]

Number of matches 36312
Number of matches After Lowe's Ratio 4406
Number of Robust matches 2209

 56%|█████     | 34/61 [01:59<01:31,  3.39s/it]

Number of matches 35698
Number of matches After Lowe's Ratio 4727
Number of Robust matches 2702

 57%|█████     | 35/61 [02:03<01:27,  3.37s/it]

Number of matches 36283
Number of matches After Lowe's Ratio 4434
Number of Robust matches 2527

 59%|█████     | 36/61 [02:06<01:24,  3.39s/it]

Number of matches 37204
Number of matches After Lowe's Ratio 4863
Number of Robust matches 2466

 61%|██████    | 37/61 [02:10<01:21,  3.41s/it]

Number of matches 38737
Number of matches After Lowe's Ratio 4183
Number of Robust matches 1938

 62%|██████    | 38/61 [02:14<01:22,  3.58s/it]

Number of matches 40144
Number of matches After Lowe's Ratio 4554
Number of Robust matches 1614

 64%|██████    | 39/61 [02:17<01:20,  3.67s/it]

Number of matches 39400
Number of matches After Lowe's Ratio 4148
Number of Robust matches 1705

 66%|██████    | 40/61 [02:21<01:16,  3.66s/it]

Number of matches 38368
Number of matches After Lowe's Ratio 5033
Number of Robust matches 2575
```

67%|▉▉▉▉▉▉ | 41/61 [02:24<01:11, 3.59s/it]

Number of matches 38791
Number of matches After Lowe's Ratio 5900
Number of Robust matches 3570

69%|▉▉▉▉▉▉ | 42/61 [02:28<01:09, 3.64s/it]

Number of matches 38100
Number of matches After Lowe's Ratio 5980
Number of Robust matches 3692

70%|▉▉▉▉▉▉▉ | 43/61 [02:32<01:04, 3.56s/it]

Number of matches 39195
Number of matches After Lowe's Ratio 6717
Number of Robust matches 4383

72%|▉▉▉▉▉▉▉ | 44/61 [02:35<01:00, 3.58s/it]

Number of matches 40180
Number of matches After Lowe's Ratio 6314
Number of Robust matches 3594

Number of matches 40454
Number of matches After Lowe's Ratio 6697

74%|▉▉▉▉▉▉▉▏ | 45/61 [02:39<00:58, 3.68s/it]

Number of Robust matches 3927

75%|▉▉▉▉▉▉▉▏ | 46/61 [02:43<00:54, 3.64s/it]

Number of matches 39823
Number of matches After Lowe's Ratio 6886
Number of Robust matches 3958

77%|▉▉▉▉▉▉▉▏ | 47/61 [02:47<00:52, 3.73s/it]

Number of matches 39851
Number of matches After Lowe's Ratio 6524
Number of Robust matches 3808

79%|▉▉▉▉▉▉▉▏ | 48/61 [02:50<00:48, 3.75s/it]

Number of matches 37448
Number of matches After Lowe's Ratio 4751
Number of Robust matches 2577

80%|▉▉▉▉▉▉▉▏ | 49/61 [02:54<00:43, 3.59s/it]

Number of matches 36805
Number of matches After Lowe's Ratio 8287
Number of Robust matches 4882

82%|▉▉▉▉▉▉▉▏ | 50/61 [02:57<00:38, 3.54s/it]

Number of matches 39522

```
Number of matches After Lowe's Ratio 7717
Number of Robust matches 4962


 84%|████████  | 51/61 [03:01<00:35,  3.56s/it]

Number of matches 38125
Number of matches After Lowe's Ratio 5347
Number of Robust matches 2675


 85%|████████  | 52/61 [03:04<00:31,  3.53s/it]

Number of matches 37529
Number of matches After Lowe's Ratio 5701
Number of Robust matches 3400


 87%|████████  | 53/61 [03:07<00:27,  3.47s/it]

Number of matches 38691
Number of matches After Lowe's Ratio 7005
Number of Robust matches 3921


 89%|████████  | 54/61 [03:11<00:24,  3.48s/it]

Number of matches 35997
Number of matches After Lowe's Ratio 4457
Number of Robust matches 2369


 90%|████████  | 55/61 [03:14<00:20,  3.40s/it]

Number of matches 35242
Number of matches After Lowe's Ratio 4490
Number of Robust matches 2353


 92%|████████  | 56/61 [03:18<00:17,  3.42s/it]

Number of matches 36041
Number of matches After Lowe's Ratio 4697
Number of Robust matches 2344


 93%|████████  | 57/61 [03:21<00:13,  3.38s/it]

Number of matches 37450
Number of matches After Lowe's Ratio 6020
Number of Robust matches 2988


 95%|████████  | 58/61 [03:24<00:10,  3.43s/it]

Number of matches 38454
Number of matches After Lowe's Ratio 3765
Number of Robust matches 1344


 97%|████████  | 59/61 [03:28<00:06,  3.45s/it]

Number of matches 38388
Number of matches After Lowe's Ratio 5337
Number of Robust matches 2133
```

```
 98%|█████████| 60/61 [03:31<00:03,  3.53s/it]
  0%|          | 0/39 [00:00<?, ?it/s]
Number of matches 38521
Number of matches After Lowe's Ratio 2380
Number of Robust matches 584

  3%|▎         | 1/39 [00:03<02:30,  3.96s/it]
Number of matches 40727
Number of matches After Lowe's Ratio 4901
Number of Robust matches 3052

  5%|▌         | 2/39 [00:07<02:17,  3.71s/it]
Number of matches 35726
Number of matches After Lowe's Ratio 4994
Number of Robust matches 3093

  8%|▊         | 3/39 [00:10<01:59,  3.33s/it]
Number of matches 29685
Number of matches After Lowe's Ratio 2598
Number of Robust matches 1056

 10%|█         | 4/39 [00:13<01:50,  3.16s/it]
Number of matches 32721
Number of matches After Lowe's Ratio 2143
Number of Robust matches 826

 13%|█▎        | 5/39 [00:15<01:40,  2.97s/it]
Number of matches 29698
Number of matches After Lowe's Ratio 4373
Number of Robust matches 2725

 15%|█▌        | 6/39 [00:19<01:41,  3.08s/it]
Number of matches 39479
Number of matches After Lowe's Ratio 3657
Number of Robust matches 1670

 18%|█▊        | 7/39 [00:22<01:42,  3.19s/it]
Number of matches 37048
Number of matches After Lowe's Ratio 6410
Number of Robust matches 4664


Number of matches 39520
Number of matches After Lowe's Ratio 7014
 21%|██        | 8/39 [00:26<01:43,  3.33s/it]
Number of Robust matches 4293
```

```
 23%|██        | 9/39 [00:29<01:40,  3.36s/it]

Number of matches 36055
Number of matches After Lowe's Ratio 5901
Number of Robust matches 3817


 26%|██        | 10/39 [00:32<01:35,  3.29s/it]

Number of matches 36244
Number of matches After Lowe's Ratio 6052
Number of Robust matches 4513


 28%|██▊       | 11/39 [00:36<01:34,  3.36s/it]

Number of matches 35202
Number of matches After Lowe's Ratio 4072
Number of Robust matches 2543


 31%|███       | 12/39 [00:39<01:28,  3.29s/it]

Number of matches 37479
Number of matches After Lowe's Ratio 4976
Number of Robust matches 2999


 33%|███▎      | 13/39 [00:42<01:26,  3.33s/it]

Number of matches 36769
Number of matches After Lowe's Ratio 4507
Number of Robust matches 2572


 36%|███▌      | 14/39 [00:46<01:23,  3.36s/it]

Number of matches 37985
Number of matches After Lowe's Ratio 4582
Number of Robust matches 2208


 38%|███▊      | 15/39 [00:50<01:23,  3.47s/it]

Number of matches 36813
Number of matches After Lowe's Ratio 4521
Number of Robust matches 2263


 41%|████      | 16/39 [00:53<01:18,  3.42s/it]

Number of matches 37749
Number of matches After Lowe's Ratio 5433
Number of Robust matches 2510


 44%|████▎     | 17/39 [00:56<01:15,  3.41s/it]

Number of matches 39377
Number of matches After Lowe's Ratio 5192
Number of Robust matches 2035


 46%|████▌     | 18/39 [01:00<01:14,  3.54s/it]

Number of matches 38479
Number of matches After Lowe's Ratio 6158
```

```
Number of Robust matches 2647

 49%|████▉     | 19/39 [01:03<01:09,  3.49s/it]

Number of matches 35539
Number of matches After Lowe's Ratio 5402
Number of Robust matches 2168

 51%|█████     | 20/39 [01:07<01:05,  3.45s/it]

Number of matches 37695
Number of matches After Lowe's Ratio 4511
Number of Robust matches 1757

 54%|█████▍    | 21/39 [01:10<01:03,  3.50s/it]

Number of matches 36113
Number of matches After Lowe's Ratio 3590
Number of Robust matches 1683

 56%|█████▋    | 22/39 [01:14<00:59,  3.50s/it]

Number of matches 40129
Number of matches After Lowe's Ratio 1632
Number of Robust matches 384

 59%|█████▉    | 23/39 [01:18<00:56,  3.56s/it]

Number of matches 40100
Number of matches After Lowe's Ratio 2525
Number of Robust matches 786

 62%|██████▏   | 24/39 [01:22<00:56,  3.76s/it]

Number of matches 40735
Number of matches After Lowe's Ratio 883
Number of Robust matches 39

 64%|██████▍   | 25/39 [01:26<00:53,  3.80s/it]

Number of matches 38881
Number of matches After Lowe's Ratio 2700
Number of Robust matches 905

 67%|██████▋   | 26/39 [01:29<00:48,  3.75s/it]

Number of matches 37388
Number of matches After Lowe's Ratio 3985
Number of Robust matches 1766

 69%|██████▉   | 27/39 [01:33<00:44,  3.68s/it]

Number of matches 35528
Number of matches After Lowe's Ratio 4435
Number of Robust matches 1746
```

72%|███████ | 28/39 [01:36<00:38, 3.51s/it]

```
Number of matches 36593
Number of matches After Lowe's Ratio 3692
Number of Robust matches 1348
```

74%|███████ | 29/39 [01:39<00:34, 3.50s/it]

```
Number of matches 40004
Number of matches After Lowe's Ratio 4536
Number of Robust matches 1321
```

77%|███████ | 30/39 [01:43<00:32, 3.57s/it]

```
Number of matches 40698
Number of matches After Lowe's Ratio 4829
Number of Robust matches 1633
```

79%|███████ | 31/39 [01:47<00:29, 3.63s/it]

```
Number of matches 40326
Number of matches After Lowe's Ratio 7549
Number of Robust matches 2687
```

82%|████████ | 32/39 [01:51<00:25, 3.60s/it]

```
Number of matches 37769
Number of matches After Lowe's Ratio 3983
Number of Robust matches 1632
```

85%|████████ | 33/39 [01:55<00:22, 3.75s/it]

```
Number of matches 34826
Number of matches After Lowe's Ratio 3983
Number of Robust matches 1843
```

87%|████████ | 34/39 [01:58<00:17, 3.53s/it]

```
Number of matches 35065
Number of matches After Lowe's Ratio 4301
Number of Robust matches 2185
```

90%|████████ | 35/39 [02:01<00:13, 3.37s/it]

```
Number of matches 34274
Number of matches After Lowe's Ratio 3875
Number of Robust matches 1898
```

92%|████████ | 36/39 [02:04<00:10, 3.39s/it]

```
Number of matches 35716
Number of matches After Lowe's Ratio 3104
Number of Robust matches 1851
```

95%|████████ | 37/39 [02:07<00:06, 3.29s/it]

```
Number of matches 36468
Number of matches After Lowe's Ratio 3953
```

Number of Robust matches 2283

97%|▉| 38/39 [02:10<00:03, 3.44s/it]

Number of matches 34147
Number of matches After Lowe's Ratio 3386
Number of Robust matches 1871

In [24]:

```
H_left_surfsift = []
H_right_surfsift = []

num_matches_surfsift = []
num_good_matches_surfsift = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_surfsift[j:j+2][::-1],points_all_left_surfsift[j:j++2][::-1],descriptors_all_left_surfs
ift[j:j+2][::-1])
    H_left_surfsift.append(H_a)
    num_matches_surfsift.append(matches)
    num_good_matches_surfsift.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_surfsift[j:j+2][::-1],points_all_right_surfsift[j:j+2][::-1],descriptors_all_right_su
rfsift[j:j+2][::-1])
    H_right_surfsift.append(H_a)
    num_matches_surfsift.append(matches)
    num_good_matches_surfsift.append(gd_matches)
```

2%|▏ | 1/61 [00:05<05:11, 5.19s/it]

Number of matches 29759
Number of matches After Lowe's Ratio 3243
Number of Robust matches 1121

3%|▎ | 2/61 [00:10<05:03, 5.14s/it]

Number of matches 31803
Number of matches After Lowe's Ratio 2821
Number of Robust matches 793

5%|▍ | 3/61 [00:15<05:00, 5.19s/it]

Number of matches 28470
Number of matches After Lowe's Ratio 586
Number of Robust matches 129

7%|▋ | 4/61 [00:20<04:42, 4.96s/it]

Number of matches 30574
Number of matches After Lowe's Ratio 6203
Number of Robust matches 2437

```
  8%|▊         | 5/61 [00:25<04:43,  5.07s/it]
Number of matches 28292
Number of matches After Lowe's Ratio 5716
Number of Robust matches 2035

 10%|▉         | 6/61 [00:29<04:28,  4.89s/it]
Number of matches 28159
Number of matches After Lowe's Ratio 5431
Number of Robust matches 2077

 11%|█         | 7/61 [00:35<04:31,  5.02s/it]
Number of matches 30159
Number of matches After Lowe's Ratio 5924
Number of Robust matches 2181

 13%|█▏        | 8/61 [00:40<04:24,  4.99s/it]
Number of matches 25112
Number of matches After Lowe's Ratio 2911
Number of Robust matches 1246

 15%|█▎        | 9/61 [00:44<04:03,  4.69s/it]
Number of matches 29686
Number of matches After Lowe's Ratio 5248
Number of Robust matches 2121

 16%|█▍        | 10/61 [00:48<03:59,  4.70s/it]
Number of matches 23395
Number of matches After Lowe's Ratio 2721
Number of Robust matches 1035

 18%|█▌        | 11/61 [00:52<03:42,  4.45s/it]
Number of matches 27431
Number of matches After Lowe's Ratio 5864
Number of Robust matches 2852

 20%|█▋        | 12/61 [00:57<03:38,  4.46s/it]
Number of matches 27034
Number of matches After Lowe's Ratio 5704
Number of Robust matches 2241

 21%|█▊        | 13/61 [01:01<03:34,  4.47s/it]
Number of matches 29867
Number of matches After Lowe's Ratio 5500
Number of Robust matches 2563

 23%|█▉        | 14/61 [01:07<03:43,  4.75s/it]
Number of matches 31522
```

Number of matches 31922
Number of matches After Lowe's Ratio 9279
Number of Robust matches 4982

25%|██▌ | 15/61 [01:12<03:44, 4.88s/it]

Number of matches 30097
Number of matches After Lowe's Ratio 6944
Number of Robust matches 4120

26%|██▋ | 16/61 [01:17<03:40, 4.90s/it]

Number of matches 30110
Number of matches After Lowe's Ratio 7490
Number of Robust matches 4271

28%|██▊ | 17/61 [01:22<03:38, 4.97s/it]

Number of matches 29782
Number of matches After Lowe's Ratio 7420
Number of Robust matches 4110

30%|██▉ | 18/61 [01:27<03:31, 4.93s/it]

Number of matches 29162
Number of matches After Lowe's Ratio 7802
Number of Robust matches 4612

31%|███ | 19/61 [01:32<03:29, 5.00s/it]

Number of matches 28941
Number of matches After Lowe's Ratio 8946
Number of Robust matches 5735

33%|███▏ | 20/61 [01:37<03:21, 4.91s/it]

Number of matches 29718
Number of matches After Lowe's Ratio 7603
Number of Robust matches 3758

34%|███▍ | 21/61 [01:42<03:23, 5.08s/it]

Number of matches 29774
Number of matches After Lowe's Ratio 6863
Number of Robust matches 2904

36%|███▌ | 22/61 [01:47<03:15, 5.02s/it]

Number of matches 28465
Number of matches After Lowe's Ratio 7451
Number of Robust matches 3767

38%|███▊ | 23/61 [01:52<03:07, 4.94s/it]

Number of matches 28901
Number of matches After Lowe's Ratio 6918
Number of Robust matches 3109

```
 39%|███▉      | 24/61 [01:56<02:59,  4.85s/it]
Number of matches 29317
Number of matches After Lowe's Ratio 6436
Number of Robust matches 3520

 41%|████      | 25/61 [02:01<02:55,  4.87s/it]
Number of matches 32274
Number of matches After Lowe's Ratio 4341
Number of Robust matches 1506

 43%|████      | 26/61 [02:07<02:56,  5.05s/it]
Number of matches 29333
Number of matches After Lowe's Ratio 4960
Number of Robust matches 1606

 44%|████      | 27/61 [02:12<02:54,  5.14s/it]
Number of matches 28791
Number of matches After Lowe's Ratio 5632
Number of Robust matches 1963

 46%|████      | 28/61 [02:17<02:48,  5.09s/it]
Number of matches 31214
Number of matches After Lowe's Ratio 5725
Number of Robust matches 1620

 48%|████      | 29/61 [02:22<02:42,  5.07s/it]
Number of matches 28464
Number of matches After Lowe's Ratio 3338
Number of Robust matches 899

 49%|████      | 30/61 [02:27<02:35,  5.02s/it]
Number of matches 29409
Number of matches After Lowe's Ratio 5152
Number of Robust matches 1937

 51%|████      | 31/61 [02:32<02:28,  4.94s/it]
Number of matches 27445
Number of matches After Lowe's Ratio 2648
Number of Robust matches 964

 52%|████      | 32/61 [02:36<02:19,  4.81s/it]
Number of matches 26763
Number of matches After Lowe's Ratio 1088
Number of Robust matches 267

 54%|████      | 33/61 [02:41<02:10,  4.67s/it]
```

```
Number of matches 27227
Number of matches After Lowe's Ratio 5182
Number of Robust matches 2267


 56%|█████▋    | 34/61 [02:45<02:05,  4.66s/it]

Number of matches 26057
Number of matches After Lowe's Ratio 6117
Number of Robust matches 2546


 57%|█████▋    | 35/61 [02:50<01:58,  4.55s/it]

Number of matches 27493
Number of matches After Lowe's Ratio 5523
Number of Robust matches 2640


 59%|█████▉    | 36/61 [02:54<01:53,  4.55s/it]

Number of matches 28655
Number of matches After Lowe's Ratio 6418
Number of Robust matches 2827


 61%|██████    | 37/61 [02:59<01:52,  4.70s/it]

Number of matches 31224
Number of matches After Lowe's Ratio 4847
Number of Robust matches 1922


 62%|██████▏   | 38/61 [03:04<01:51,  4.84s/it]

Number of matches 32243
Number of matches After Lowe's Ratio 5660
Number of Robust matches 1636


 64%|██████▍   | 39/61 [03:10<01:51,  5.09s/it]

Number of matches 31404
Number of matches After Lowe's Ratio 5023
Number of Robust matches 1733


 66%|██████▌   | 40/61 [03:15<01:45,  5.05s/it]

Number of matches 29941
Number of matches After Lowe's Ratio 6481
Number of Robust matches 2831


 67%|██████▋   | 41/61 [03:20<01:43,  5.19s/it]

Number of matches 29731
Number of matches After Lowe's Ratio 6933
Number of Robust matches 3577


 69%|██████▉   | 42/61 [03:25<01:35,  5.02s/it]

Number of matches 29003
Number of matches After Lowe's Ratio 7217
Number of Robust matches 3885
```

70%|███████ | 43/61 [03:30<01:28, 4.92s/it]

```
Number of matches 29540
Number of matches After Lowe's Ratio 8434
Number of Robust matches 4640
```

72%|███████ | 44/61 [03:35<01:24, 4.98s/it]

```
Number of matches 30714
Number of matches After Lowe's Ratio 7701
Number of Robust matches 4016
```

74%|███████ | 45/61 [03:40<01:20, 5.03s/it]

```
Number of matches 31999
Number of matches After Lowe's Ratio 8178
Number of Robust matches 3831
```

75%|███████ | 46/61 [03:46<01:17, 5.17s/it]

```
Number of matches 31349
Number of matches After Lowe's Ratio 8515
Number of Robust matches 4411
```

77%|███████ | 47/61 [03:51<01:14, 5.33s/it]

```
Number of matches 31491
Number of matches After Lowe's Ratio 7721
Number of Robust matches 3217
```

79%|███████ | 48/61 [03:57<01:09, 5.33s/it]

```
Number of matches 29793
Number of matches After Lowe's Ratio 4652
Number of Robust matches 2092
```

80%|███████ | 49/61 [04:01<01:02, 5.20s/it]

```
Number of matches 28686
Number of matches After Lowe's Ratio 8545
Number of Robust matches 4323
```

82%|███████ | 50/61 [04:06<00:55, 5.09s/it]

```
Number of matches 29518
Number of matches After Lowe's Ratio 8914
Number of Robust matches 5410
```

84%|███████ | 51/61 [04:11<00:49, 4.96s/it]

```
Number of matches 27220
Number of matches After Lowe's Ratio 5417
Number of Robust matches 2995
```

85%|███████ | 52/61 [04:16<00:43, 4.86s/it]

```
Number of matches 27631
Number of matches After Lowe's Ratio 5599
Number of Robust matches 2724


 87%|████████  | 53/61 [04:20<00:37,  4.71s/it]

Number of matches 28608
Number of matches After Lowe's Ratio 7287
Number of Robust matches 4061


 89%|████████  | 54/61 [04:25<00:34,  4.86s/it]

Number of matches 27793
Number of matches After Lowe's Ratio 5353
Number of Robust matches 2506


 90%|████████  | 55/61 [04:30<00:28,  4.76s/it]

Number of matches 26647
Number of matches After Lowe's Ratio 5579
Number of Robust matches 2742


 92%|████████  | 56/61 [04:34<00:22,  4.56s/it]

Number of matches 27094
Number of matches After Lowe's Ratio 5090
Number of Robust matches 2207


 93%|████████  | 57/61 [04:38<00:18,  4.58s/it]

Number of matches 28742
Number of matches After Lowe's Ratio 7469
Number of Robust matches 2644


 95%|████████  | 58/61 [04:43<00:13,  4.63s/it]

Number of matches 28988
Number of matches After Lowe's Ratio 4159
Number of Robust matches 1204


 97%|████████  | 59/61 [04:48<00:09,  4.71s/it]

Number of matches 29103
Number of matches After Lowe's Ratio 6566
Number of Robust matches 2083


 98%|████████  | 60/61 [04:53<00:04,  4.89s/it]
  0%|          | 0/39 [00:00<?, ?it/s]

Number of matches 28791
Number of matches After Lowe's Ratio 1689
Number of Robust matches 425


  3%|          | 1/39 [00:05<03:28,  5.48s/it]

Number of matches 30994
Number of matches After Lowe's Ratio 5765
Number of Robust matches 2795
```

Number of Robust matches 2785

```
  5%|▌         | 2/39 [00:10<03:11,  5.16s/it]
```

```
Number of matches 27439
Number of matches After Lowe's Ratio 5520
Number of Robust matches 2945
```

```
  8%|▊         | 3/39 [00:14<02:48,  4.67s/it]
```

```
Number of matches 22006
Number of matches After Lowe's Ratio 2722
Number of Robust matches 1295
```

```
 10%|█         | 4/39 [00:18<02:29,  4.26s/it]
```

```
Number of matches 25745
Number of matches After Lowe's Ratio 1721
Number of Robust matches 749
```

```
 13%|█▎        | 5/39 [00:22<02:22,  4.19s/it]
```

```
Number of matches 23382
Number of matches After Lowe's Ratio 5821
Number of Robust matches 3050
```

```
 15%|█▌        | 6/39 [00:26<02:15,  4.10s/it]
```

```
Number of matches 32804
Number of matches After Lowe's Ratio 3364
Number of Robust matches 1806
```

```
Number of matches 30475
Number of matches After Lowe's Ratio 10364
```

```
 18%|█▊        | 7/39 [00:32<02:29,  4.69s/it]
```

```
Number of Robust matches 5718
```

```
 21%|██        | 8/39 [00:37<02:34,  4.98s/it]
```

```
Number of matches 32449
Number of matches After Lowe's Ratio 10423
Number of Robust matches 6268
```

```
 23%|██▎       | 9/39 [00:43<02:33,  5.13s/it]
```

```
Number of matches 28137
Number of matches After Lowe's Ratio 7824
Number of Robust matches 4207
```

```
 26%|██▌       | 10/39 [00:47<02:25,  5.02s/it]
```

```
Number of matches 28712
Number of matches After Lowe's Ratio 8570
Number of Robust matches 4861
```

```
 28%|██▊       | 11/39 [00:52<02:19,  4.99s/it]
Number of matches 27853
Number of matches After Lowe's Ratio 6003
Number of Robust matches 3008

 31%|███       | 12/39 [00:57<02:10,  4.84s/it]
Number of matches 29532
Number of matches After Lowe's Ratio 7884
Number of Robust matches 4168

 33%|███▎      | 13/39 [01:02<02:08,  4.95s/it]
Number of matches 30289
Number of matches After Lowe's Ratio 7547
Number of Robust matches 3474

 36%|███▌      | 14/39 [01:07<02:05,  5.02s/it]
Number of matches 31517
Number of matches After Lowe's Ratio 8712
Number of Robust matches 3520

 38%|███▊      | 15/39 [01:13<02:06,  5.27s/it]
Number of matches 30146
Number of matches After Lowe's Ratio 7826
Number of Robust matches 3603

 41%|████      | 16/39 [01:18<02:00,  5.24s/it]
Number of matches 31185
Number of matches After Lowe's Ratio 8903
Number of Robust matches 3619

 44%|████▎     | 17/39 [01:24<01:56,  5.31s/it]
Number of matches 32266
Number of matches After Lowe's Ratio 7876
Number of Robust matches 3003


Number of matches 31322
Number of matches After Lowe's Ratio 9685
 46%|████▌     | 18/39 [01:29<01:52,  5.37s/it]
Number of Robust matches 3474

 49%|████▊     | 19/39 [01:34<01:45,  5.30s/it]
Number of matches 27735
Number of matches After Lowe's Ratio 7545
Number of Robust matches 2635

 51%|█████     | 20/39 [01:39<01:36,  5.10s/it]
```

```
Number of matches 30089
Number of matches After Lowe's Ratio 7657
Number of Robust matches 2680


 54%|█████     | 21/39 [01:45<01:34,  5.25s/it]

Number of matches 27897
Number of matches After Lowe's Ratio 6039
Number of Robust matches 2456


 56%|█████▋    | 22/39 [01:49<01:26,  5.07s/it]

Number of matches 32011
Number of matches After Lowe's Ratio 1891
Number of Robust matches 582


 59%|█████▉    | 23/39 [01:54<01:21,  5.11s/it]

Number of matches 30610
Number of matches After Lowe's Ratio 3953
Number of Robust matches 1131


 62%|██████    | 24/39 [02:00<01:17,  5.19s/it]

Number of matches 34036
Number of matches After Lowe's Ratio 82
Number of Robust matches 13


 64%|██████▍   | 25/39 [02:05<01:14,  5.29s/it]

Number of matches 31567
Number of matches After Lowe's Ratio 3461
Number of Robust matches 1126


 67%|██████▋   | 26/39 [02:11<01:08,  5.29s/it]

Number of matches 29422
Number of matches After Lowe's Ratio 7205
Number of Robust matches 2686


 69%|██████▉   | 27/39 [02:16<01:03,  5.28s/it]

Number of matches 28350
Number of matches After Lowe's Ratio 6063
Number of Robust matches 2258


 72%|███████   | 28/39 [02:21<00:56,  5.14s/it]

Number of matches 28706
Number of matches After Lowe's Ratio 5699
Number of Robust matches 1527


 74%|███████▍  | 29/39 [02:25<00:50,  5.02s/it]

Number of matches 32873
Number of matches After Lowe's Ratio 5388
Number of Robust matches 1396
```

```
 77%|███████▊  | 30/39 [02:31<00:47,  5.29s/it]
Number of matches 33122
Number of matches After Lowe's Ratio 5765
Number of Robust matches 1595

 79%|███████▉  | 31/39 [02:37<00:43,  5.41s/it]
Number of matches 32633
Number of matches After Lowe's Ratio 9386
Number of Robust matches 3168

 82%|████████  | 32/39 [02:43<00:38,  5.54s/it]
Number of matches 29972
Number of matches After Lowe's Ratio 5365
Number of Robust matches 1819

 85%|████████▏ | 33/39 [02:48<00:32,  5.46s/it]
Number of matches 27587
Number of matches After Lowe's Ratio 7373
Number of Robust matches 2595

 87%|████████▎ | 34/39 [02:53<00:26,  5.23s/it]
Number of matches 28008
Number of matches After Lowe's Ratio 6567
Number of Robust matches 2752

 90%|████████▍ | 35/39 [02:58<00:20,  5.07s/it]
Number of matches 26930
Number of matches After Lowe's Ratio 5074
Number of Robust matches 2281

 92%|████████▌ | 36/39 [03:02<00:14,  4.89s/it]
Number of matches 26784
Number of matches After Lowe's Ratio 3704
Number of Robust matches 1614

 95%|████████▋ | 37/39 [03:06<00:09,  4.72s/it]
Number of matches 27835
Number of matches After Lowe's Ratio 5424
Number of Robust matches 3110

 97%|████████▊ | 38/39 [03:11<00:05,  5.04s/it]
Number of matches 26661
Number of matches After Lowe's Ratio 5345
Number of Robust matches 2436
```

In [21]:

```
H_left_agast = []
H_right_agast = []

num_matches_agast = []
num_good_matches_agast = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_agast[j:j+2][::-1],points_all_left_agast[j:j+2][::-1],descriptors_all_left_agast[j:j+2]
[::-1])
    H_left_agast.append(H_a)
    num_matches_agast.append(matches)
    num_good_matches_agast.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_agast[j:j+2][::-1],points_all_right_agast[j:j+2][::-1],descriptors_all_right_agast[j:
j+2][::-1])
    H_right_agast.append(H_a)
    num_matches_agast.append(matches)
    num_good_matches_agast.append(gd_matches)
```

```
  2%|▏         | 1/61 [00:23<23:46, 23.78s/it]
```

```
Number of matches 123626
Number of matches After Lowe's Ratio 4748
Number of Robust matches 2079
```

```
  3%|▎         | 2/61 [00:49<24:26, 24.85s/it]
```

```
Number of matches 135893
Number of matches After Lowe's Ratio 1777
Number of Robust matches 558
```

```
  5%|▍         | 3/61 [01:15<24:28, 25.32s/it]
```

```
Number of matches 119233
Number of matches After Lowe's Ratio 238
Number of Robust matches 87
```

```
  7%|▋         | 4/61 [01:39<23:29, 24.72s/it]
```

```
Number of matches 119944
Number of matches After Lowe's Ratio 14757
Number of Robust matches 8113
```

```
  8%|▊         | 5/61 [02:03<22:54, 24.55s/it]
```

```
Number of matches 127483
Number of matches After Lowe's Ratio 1234
Number of Robust matches 386
```

```
 10%|▉         | 6/61 [02:28<22:40, 24.74s/it]
```

```
Number of matches 120719
Number of matches After Lowe's Ratio 4685
Number of Robust matches 1988
```

Number of Robust matches 1900

11%|▉ | 7/61 [02:53<22:23, 24.87s/it]

Number of matches 127159
Number of matches After Lowe's Ratio 2510
Number of Robust matches 1396

13%|▉ | 8/61 [03:17<21:48, 24.69s/it]

Number of matches 100181
Number of matches After Lowe's Ratio 7033
Number of Robust matches 3978

15%|▉ | 9/61 [03:38<20:14, 23.36s/it]

Number of matches 113929
Number of matches After Lowe's Ratio 6298
Number of Robust matches 3920

16%|▉ | 10/61 [03:59<19:12, 22.60s/it]

Number of matches 72363
Number of matches After Lowe's Ratio 2554
Number of Robust matches 1555

18%|▉ | 11/61 [04:15<17:07, 20.55s/it]

Number of matches 98954
Number of matches After Lowe's Ratio 9423
Number of Robust matches 6569

20%|▉ | 12/61 [04:34<16:26, 20.14s/it]

Number of matches 79366
Number of matches After Lowe's Ratio 587
Number of Robust matches 263

21%|▉ | 13/61 [04:51<15:27, 19.32s/it]

Number of matches 110204
Number of matches After Lowe's Ratio 3250
Number of Robust matches 1978

23%|▉ | 14/61 [05:13<15:40, 20.02s/it]

Number of matches 105901
Number of matches After Lowe's Ratio 7170
Number of Robust matches 4532

Number of matches 107504
Number of matches After Lowe's Ratio 9763

25%|▉ | 15/61 [05:34<15:40, 20.45s/it]

Number of Robust matches 6580

```
Number of matches 103271
Number of matches After Lowe's Ratio 6660
 26%|██        | 16/61 [05:55<15:20, 20.47s/it]
Number of Robust matches 4946


 28%|██        | 17/61 [06:17<15:18, 20.88s/it]
Number of matches 116933
Number of matches After Lowe's Ratio 11489
Number of Robust matches 8198


Number of matches 119028
Number of matches After Lowe's Ratio 25363
 30%|██        | 18/61 [06:41<15:43, 21.95s/it]
Number of Robust matches 17365


 31%|███       | 19/61 [07:05<15:50, 22.62s/it]
Number of matches 124258
Number of matches After Lowe's Ratio 22409
Number of Robust matches 17309


 33%|███       | 20/61 [07:31<16:02, 23.48s/it]
Number of matches 131124
Number of matches After Lowe's Ratio 13218
Number of Robust matches 8702


 34%|███       | 21/61 [07:58<16:19, 24.48s/it]
Number of matches 134054
Number of matches After Lowe's Ratio 4528
Number of Robust matches 2610


Number of matches 127609
Number of matches After Lowe's Ratio 24180
Number of Robust matches 15254


 38%|███       | 23/61 [08:50<15:59, 25.25s/it]
Number of matches 124545
Number of matches After Lowe's Ratio 4986
Number of Robust matches 2469


 39%|███       | 24/61 [09:15<15:34, 25.26s/it]
Number of matches 130795
Number of matches After Lowe's Ratio 17904
Number of Robust matches 9331


 41%|████      | 25/61 [09:42<15:24, 25.69s/it]
Number of matches 141804
```

```
Number of matches After Lowe's Ratio 89
Number of Robust matches 18


 43%|████      | 26/61 [10:10<15:24, 26.41s/it]

Number of matches 128214
Number of matches After Lowe's Ratio 618
Number of Robust matches 154


 44%|████      | 27/61 [10:36<14:51, 26.21s/it]

Number of matches 130355
Number of matches After Lowe's Ratio 11545
Number of Robust matches 6219


 46%|████      | 28/61 [11:01<14:13, 25.86s/it]

Number of matches 120660
Number of matches After Lowe's Ratio 404
Number of Robust matches 110


 48%|████      | 29/61 [11:25<13:35, 25.49s/it]

Number of matches 137824
Number of matches After Lowe's Ratio 231
Number of Robust matches 73


 49%|████      | 30/61 [11:53<13:31, 26.18s/it]

Number of matches 141614
Number of matches After Lowe's Ratio 6788
Number of Robust matches 3228


 51%|█████     | 31/61 [12:21<13:19, 26.64s/it]

Number of matches 131535
Number of matches After Lowe's Ratio 4367
Number of Robust matches 1675


 52%|█████     | 32/61 [12:47<12:52, 26.64s/it]

Number of matches 127536
Number of matches After Lowe's Ratio 68
Number of Robust matches 11


Number of matches 129839
Number of matches After Lowe's Ratio 20537
 54%|█████     | 33/61 [13:13<12:13, 26.19s/it]

Number of Robust matches 13151


Number of matches 126651
Number of matches After Lowe's Ratio 18866
 56%|█████     | 34/61 [13:39<11:47, 26.20s/it]

Number of Robust matches 11528
```

Number of Robust matches 11528

57%|[redacted]| 35/61 [14:04<11:15, 25.97s/it]

Number of matches 135662
Number of matches After Lowe's Ratio 17031
Number of Robust matches 10535

59%|[redacted]| 36/61 [14:31<10:55, 26.24s/it]

Number of matches 139772
Number of matches After Lowe's Ratio 13691
Number of Robust matches 7559

61%|[redacted]| 37/61 [15:00<10:45, 26.90s/it]

Number of matches 152790
Number of matches After Lowe's Ratio 19057
Number of Robust matches 9153

Number of matches 158880
Number of matches After Lowe's Ratio 21245
Number of Robust matches 8679

64%|[redacted]| 39/61 [16:02<10:38, 29.02s/it]

Number of matches 152717
Number of matches After Lowe's Ratio 20031
Number of Robust matches 11644

66%|[redacted]| 40/61 [16:30<10:07, 28.94s/it]

Number of matches 132257
Number of matches After Lowe's Ratio 21128
Number of Robust matches 11834

Number of matches 126012
Number of matches After Lowe's Ratio 25478
Number of Robust matches 14572

69%|[redacted]| 42/61 [17:22<08:39, 27.33s/it]

Number of matches 118729
Number of matches After Lowe's Ratio 25196
Number of Robust matches 18161

70%|[redacted]| 43/61 [17:46<07:54, 26.38s/it]

Number of matches 112501
Number of matches After Lowe's Ratio 21273
Number of Robust matches 13937

72%|[redacted]| 44/61 [18:10<07:13, 25.52s/it]

Number of matches 120367
Number of matches After Lowe's Ratio 21413

Number of Robust matches 12237

Number of matches 128900
Number of matches After Lowe's Ratio 22855
 74%|███████ | 45/61 [18:36<06:50, 25.63s/it]
Number of Robust matches 15387

 75%|███████ | 46/61 [19:02<06:27, 25.82s/it]
Number of matches 118239
Number of matches After Lowe's Ratio 23913
Number of Robust matches 17494

 77%|███████ | 47/61 [19:27<05:56, 25.43s/it]
Number of matches 117746
Number of matches After Lowe's Ratio 17869
Number of Robust matches 10940

 79%|███████ | 48/61 [19:49<05:18, 24.51s/it]
Number of matches 94610
Number of matches After Lowe's Ratio 9216
Number of Robust matches 7041

 80%|████████ | 49/61 [20:09<04:37, 23.13s/it]
Number of matches 93123
Number of matches After Lowe's Ratio 22682
Number of Robust matches 15186

 82%|████████ | 50/61 [20:28<04:01, 21.91s/it]
Number of matches 94525
Number of matches After Lowe's Ratio 16493
Number of Robust matches 12083

Number of matches 97507
Number of matches After Lowe's Ratio 17482
 84%|████████ | 51/61 [20:47<03:30, 21.01s/it]
Number of Robust matches 11911

 85%|████████ | 52/61 [21:06<03:04, 20.50s/it]
Number of matches 93618
Number of matches After Lowe's Ratio 16473
Number of Robust matches 11478

 87%|████████ | 53/61 [21:25<02:40, 20.02s/it]
Number of matches 100100
Number of matches After Lowe's Ratio 24841
Number of Robust matches 14576

```
 89%|████████▉ | 54/61 [21:46<02:21, 20.20s/it]
Number of matches 102617
Number of matches After Lowe's Ratio 7470
Number of Robust matches 3965

 90%|█████████ | 55/61 [22:07<02:03, 20.52s/it]
Number of matches 103996
Number of matches After Lowe's Ratio 5155
Number of Robust matches 2802

 92%|█████████▏ | 56/61 [22:29<01:44, 20.98s/it]
Number of matches 112006
Number of matches After Lowe's Ratio 11163
Number of Robust matches 5035

 93%|█████████▎ | 57/61 [22:52<01:26, 21.70s/it]
Number of matches 111932
Number of matches After Lowe's Ratio 9457
Number of Robust matches 4623

 95%|█████████▍ | 58/61 [23:16<01:07, 22.35s/it]
Number of matches 115210
Number of matches After Lowe's Ratio 5840
Number of Robust matches 2758

 97%|█████████▋ | 59/61 [23:40<00:45, 22.72s/it]
Number of matches 116566
Number of matches After Lowe's Ratio 11748
Number of Robust matches 5484

 98%|█████████▊ | 60/61 [24:03<00:24, 24.06s/it]
  0%|           | 0/39 [00:00<?, ?it/s]
Number of matches 108059
Number of matches After Lowe's Ratio 1121
Number of Robust matches 362

  3%|▎          | 1/39 [00:24<15:45, 24.88s/it]
Number of matches 136160
Number of matches After Lowe's Ratio 19029
Number of Robust matches 12470

  5%|▌          | 2/39 [00:50<15:44, 25.53s/it]
Number of matches 106595
Number of matches After Lowe's Ratio 16130
Number of Robust matches 10450
```

```
  8%|▊         | 3/39 [01:09<13:24, 22.35s/it]

Number of matches 58345
Number of matches After Lowe's Ratio 5307
Number of Robust matches 4103


 10%|▉         | 4/39 [01:22<10:53, 18.66s/it]

Number of matches 81499
Number of matches After Lowe's Ratio 3475
Number of Robust matches 2265


 13%|▉         | 5/39 [01:37<09:50, 17.38s/it]

Number of matches 63079
Number of matches After Lowe's Ratio 9696
Number of Robust matches 6464


 15%|▉         | 6/39 [01:53<09:17, 16.89s/it]

Number of matches 114291
Number of matches After Lowe's Ratio 8630
Number of Robust matches 4626


 18%|▉         | 7/39 [02:16<10:03, 18.85s/it]

Number of matches 116170
Number of matches After Lowe's Ratio 18943
Number of Robust matches 11866


Number of matches 119668
Number of matches After Lowe's Ratio 18942
 21%|▉         | 8/39 [02:40<10:32, 20.39s/it]

Number of Robust matches 15185


 23%|▉         | 9/39 [03:04<10:53, 21.78s/it]

Number of matches 117998
Number of matches After Lowe's Ratio 22959
Number of Robust matches 18735


Number of matches 132866
Number of matches After Lowe's Ratio 33090
 26%|▉         | 10/39 [03:30<11:05, 22.94s/it]

Number of Robust matches 24957


 28%|▉         | 11/39 [03:57<11:21, 24.32s/it]

Number of matches 140126
Number of matches After Lowe's Ratio 9394
Number of Robust matches 5770


 31%|▉         | 12/39 [04:26<11:29, 25.53s/it]
```

```
Number of matches 141469
Number of matches After Lowe's Ratio 14941
Number of Robust matches 9895


 33%|███       | 13/39 [04:55<11:30, 26.56s/it]

Number of matches 145304
Number of matches After Lowe's Ratio 18167
Number of Robust matches 10896


 36%|███       | 14/39 [05:23<11:21, 27.26s/it]

Number of matches 140550
Number of matches After Lowe's Ratio 12963
Number of Robust matches 8074


 38%|███▊      | 15/39 [05:51<10:59, 27.49s/it]

Number of matches 145499
Number of matches After Lowe's Ratio 9475
Number of Robust matches 4650


 41%|████      | 16/39 [06:20<10:41, 27.88s/it]

Number of matches 131418
Number of matches After Lowe's Ratio 16962
Number of Robust matches 9013


 44%|████▎     | 17/39 [06:46<09:56, 27.13s/it]

Number of matches 118887
Number of matches After Lowe's Ratio 13518
Number of Robust matches 6699


 46%|████▌     | 18/39 [07:10<09:09, 26.19s/it]

Number of matches 120713
Number of matches After Lowe's Ratio 21224
Number of Robust matches 11489


 49%|████▊     | 19/39 [07:34<08:35, 25.78s/it]

Number of matches 119094
Number of matches After Lowe's Ratio 21429
Number of Robust matches 9565


 51%|█████     | 20/39 [07:58<07:55, 25.02s/it]

Number of matches 110691
Number of matches After Lowe's Ratio 6602
Number of Robust matches 2936


 54%|█████▍    | 21/39 [08:20<07:16, 24.24s/it]

Number of matches 128357
Number of matches After Lowe's Ratio 8120
Number of Robust matches 4166
```

56%|[redacted]| 22/39 [08:47<07:04, 24.95s/it]

```
Number of matches 157198
Number of matches After Lowe's Ratio 3074
Number of Robust matches 1240
```

59%|[redacted]| 23/39 [09:17<07:05, 26.60s/it]

```
Number of matches 141400
Number of matches After Lowe's Ratio 12966
Number of Robust matches 5339
```

62%|[redacted]| 24/39 [09:46<06:49, 27.33s/it]

```
Number of matches 162834
Number of matches After Lowe's Ratio 50
Number of Robust matches 15
```

64%|[redacted]| 25/39 [10:17<06:36, 28.33s/it]

```
Number of matches 136771
Number of matches After Lowe's Ratio 10642
Number of Robust matches 4065
```

67%|[redacted]| 26/39 [10:44<06:02, 27.90s/it]

```
Number of matches 139861
Number of matches After Lowe's Ratio 7038
Number of Robust matches 2159
```

69%|[redacted]| 27/39 [11:10<05:30, 27.54s/it]

```
Number of matches 121764
Number of matches After Lowe's Ratio 16846
Number of Robust matches 7286
```

72%|[redacted]| 28/39 [11:35<04:51, 26.54s/it]

```
Number of matches 110405
Number of matches After Lowe's Ratio 5285
Number of Robust matches 2566
```

```
Number of matches 96942
Number of matches After Lowe's Ratio 10268
```

74%|[redacted]| 29/39 [11:56<04:09, 24.95s/it]

```
Number of Robust matches 3948
```

77%|[redacted]| 30/39 [12:16<03:30, 23.43s/it]

```
Number of matches 106417
Number of matches After Lowe's Ratio 15742
Number of Robust matches 5890
```

```
Number of matches 110856
Number of matches After Lowe's Ratio 27052
 79%|███████▉  | 31/39 [12:39<03:07, 23.42s/it]
Number of Robust matches 10488


 82%|████████▏ | 32/39 [13:02<02:42, 23.25s/it]
Number of matches 119085
Number of matches After Lowe's Ratio 13364
Number of Robust matches 5860


 85%|████████▍ | 33/39 [13:26<02:20, 23.43s/it]
Number of matches 119392
Number of matches After Lowe's Ratio 610
Number of Robust matches 161


 87%|████████▋ | 34/39 [13:50<01:57, 23.49s/it]
Number of matches 128047
Number of matches After Lowe's Ratio 10044
Number of Robust matches 5639


 90%|████████▉ | 35/39 [14:15<01:36, 24.02s/it]
Number of matches 121827
Number of matches After Lowe's Ratio 7574
Number of Robust matches 3441


 92%|█████████▏| 36/39 [14:39<01:12, 24.18s/it]
Number of matches 133957
Number of matches After Lowe's Ratio 5123
Number of Robust matches 3627


 95%|█████████▍| 37/39 [15:06<00:49, 25.00s/it]
Number of matches 132546
Number of matches After Lowe's Ratio 9842
Number of Robust matches 6858



Number of matches 122243
Number of matches After Lowe's Ratio 7776
 97%|█████████▋| 38/39 [15:32<00:24, 24.55s/it]
Number of Robust matches 4651
```

In [20]:

```
H_left_akaze = []
H_right_akaze = []

num_matches_akaze = []
num_good_matches_akaze = []
```

```
for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_akaze[j:j+2][::-1],points_all_left_akaze[j:j+2][::-1],descriptors_all_left_akaze[j:j+2]
[::-1])
    H_left_akaze.append(H_a)
    num_matches_akaze.append(matches)
    num_good_matches_akaze.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_akaze[j:j+2][::-1],points_all_right_akaze[j:j+2][::-1],descriptors_all_right_akaze[j:
j+2][::-1])
    H_right_akaze.append(H_a)
    num_matches_akaze.append(matches)
    num_good_matches_akaze.append(gd_matches)
```

```
  2%|▏          | 1/61 [00:01<01:04,  1.07s/it]
```

```
Number of matches 16167
Number of matches After Lowe's Ratio 1027
Number of Robust matches 472
```

```
  3%|▎          | 2/61 [00:02<01:05,  1.10s/it]
```

```
Number of matches 21720
Number of matches After Lowe's Ratio 895
Number of Robust matches 281
```

```
  5%|▍          | 3/61 [00:03<01:19,  1.37s/it]
```

```
Number of matches 18547
Number of matches After Lowe's Ratio 435
Number of Robust matches 30
```

```
  7%|▋          | 4/61 [00:05<01:15,  1.32s/it]
```

```
Number of matches 18110
Number of matches After Lowe's Ratio 2321
Number of Robust matches 1326
```

```
  8%|▊          | 5/61 [00:06<01:11,  1.27s/it]
```

```
Number of matches 18754
Number of matches After Lowe's Ratio 2306
Number of Robust matches 1263
```

```
 10%|▉          | 6/61 [00:07<01:11,  1.31s/it]
```

```
Number of matches 19049
Number of matches After Lowe's Ratio 2386
Number of Robust matches 1241
```

```
 11%|█          | 7/61 [00:08<01:10,  1.30s/it]
```

```
Number of matches 20428
Number of matches After Lowe's Ratio 2565
Number of Robust matches 1496
```

```
 13%|▉         | 8/61 [00:10<01:09,  1.31s/it]
Number of matches 15748
Number of matches After Lowe's Ratio 1171
Number of Robust matches 597

 15%|▉         | 9/61 [00:11<01:04,  1.23s/it]
Number of matches 21469
Number of matches After Lowe's Ratio 2012
Number of Robust matches 1350

 16%|▉         | 10/61 [00:12<01:07,  1.32s/it]
Number of matches 15853
Number of matches After Lowe's Ratio 1134
Number of Robust matches 647

 18%|▉         | 11/61 [00:14<01:12,  1.45s/it]
Number of matches 20465
Number of matches After Lowe's Ratio 2259
Number of Robust matches 1662

 20%|▉         | 12/61 [00:15<01:09,  1.42s/it]
Number of matches 19280
Number of matches After Lowe's Ratio 2669
Number of Robust matches 2040

 21%|▉         | 13/61 [00:17<01:06,  1.38s/it]
Number of matches 21349
Number of matches After Lowe's Ratio 2749
Number of Robust matches 1796

 23%|▉         | 14/61 [00:18<01:06,  1.41s/it]
Number of matches 21345
Number of matches After Lowe's Ratio 4147
Number of Robust matches 3079

 25%|▉         | 15/61 [00:20<01:05,  1.42s/it]
Number of matches 20541
Number of matches After Lowe's Ratio 3171
Number of Robust matches 2278

 26%|▉         | 16/61 [00:21<01:05,  1.45s/it]
Number of matches 19544
Number of matches After Lowe's Ratio 3457
Number of Robust matches 2377

 28%|▉         | 17/61 [00:23<01:02,  1.42s/it]
```

Number of matches 19557
Number of matches After Lowe's Ratio 3227
Number of Robust matches 2620

30%|███ | 18/61 [00:24<01:02, 1.46s/it]

Number of matches 19398
Number of matches After Lowe's Ratio 4148
Number of Robust matches 3464

31%|███ | 19/61 [00:25<00:59, 1.42s/it]

Number of matches 19838
Number of matches After Lowe's Ratio 4524
Number of Robust matches 3486

33%|███ | 20/61 [00:27<00:58, 1.44s/it]

Number of matches 19744
Number of matches After Lowe's Ratio 4052
Number of Robust matches 2733

34%|███ | 21/61 [00:28<00:56, 1.40s/it]

Number of matches 20624
Number of matches After Lowe's Ratio 3427
Number of Robust matches 2227

36%|███ | 22/61 [00:30<00:54, 1.40s/it]

Number of matches 19950
Number of matches After Lowe's Ratio 3082
Number of Robust matches 1910

38%|███ | 23/61 [00:31<00:52, 1.39s/it]

Number of matches 20566
Number of matches After Lowe's Ratio 2843
Number of Robust matches 1550

39%|███ | 24/61 [00:32<00:51, 1.40s/it]

Number of matches 20559
Number of matches After Lowe's Ratio 2365
Number of Robust matches 1236

41%|███ | 25/61 [00:34<00:52, 1.45s/it]

Number of matches 24258
Number of matches After Lowe's Ratio 2020
Number of Robust matches 1075

43%|███ | 26/61 [00:36<00:55, 1.60s/it]

Number of matches 20958
Number of matches After Lowe's Ratio 1793

Number of Robust matches 791

44%|████ | 27/61 [00:37<00:53, 1.58s/it]

Number of matches 22246
Number of matches After Lowe's Ratio 2199
Number of Robust matches 1042

46%|████ | 28/61 [00:39<00:51, 1.57s/it]

Number of matches 20947
Number of matches After Lowe's Ratio 2185
Number of Robust matches 1038

48%|████ | 29/61 [00:41<00:49, 1.55s/it]

Number of matches 24081
Number of matches After Lowe's Ratio 1472
Number of Robust matches 703

49%|████ | 30/61 [00:42<00:50, 1.63s/it]

Number of matches 22618
Number of matches After Lowe's Ratio 1630
Number of Robust matches 725

51%|████ | 31/61 [00:44<00:49, 1.65s/it]

Number of matches 23539
Number of matches After Lowe's Ratio 939
Number of Robust matches 330

52%|████ | 32/61 [00:46<00:52, 1.82s/it]

Number of matches 19832
Number of matches After Lowe's Ratio 517
Number of Robust matches 75

54%|████ | 33/61 [00:48<00:46, 1.67s/it]

Number of matches 19393
Number of matches After Lowe's Ratio 1912
Number of Robust matches 1126

56%|████ | 34/61 [00:49<00:42, 1.59s/it]

Number of matches 17976
Number of matches After Lowe's Ratio 1986
Number of Robust matches 1246

57%|████ | 35/61 [00:50<00:38, 1.47s/it]

Number of matches 19408
Number of matches After Lowe's Ratio 2078
Number of Robust matches 1310

59%|▉▉▉▉▉▉ | 36/61 [00:52<00:35, 1.43s/it]

```
Number of matches 23039
Number of matches After Lowe's Ratio 2452
Number of Robust matches 1337
```

61%|▉▉▉▉▉▉ | 37/61 [00:53<00:36, 1.51s/it]

```
Number of matches 26557
Number of matches After Lowe's Ratio 2010
Number of Robust matches 915
```

62%|▉▉▉▉▉▉ | 38/61 [00:55<00:38, 1.69s/it]

```
Number of matches 28674
Number of matches After Lowe's Ratio 2309
Number of Robust matches 738
```

64%|▉▉▉▉▉▉ | 39/61 [00:58<00:41, 1.90s/it]

```
Number of matches 25251
Number of matches After Lowe's Ratio 2281
Number of Robust matches 1158
```

66%|▉▉▉▉▉▉ | 40/61 [00:59<00:39, 1.87s/it]

```
Number of matches 22062
Number of matches After Lowe's Ratio 2503
Number of Robust matches 1432
```

67%|▉▉▉▉▉▉ | 41/61 [01:01<00:35, 1.78s/it]

```
Number of matches 20521
Number of matches After Lowe's Ratio 2816
Number of Robust matches 1848
```

69%|▉▉▉▉▉▉ | 42/61 [01:02<00:31, 1.65s/it]

```
Number of matches 19126
Number of matches After Lowe's Ratio 2970
Number of Robust matches 2036
```

70%|▉▉▉▉▉▉ | 43/61 [01:04<00:28, 1.58s/it]

```
Number of matches 20186
Number of matches After Lowe's Ratio 3466
Number of Robust matches 1976
```

72%|▉▉▉▉▉▉ | 44/61 [01:05<00:25, 1.52s/it]

```
Number of matches 21213
Number of matches After Lowe's Ratio 3189
Number of Robust matches 2234
```

74%|▉▉▉▉▉▉ | 45/61 [01:07<00:24, 1.51s/it]

```
Number of matches 21932
Number of matches After Lowe's Ratio 3637
```

```
Number of Robust matches 2271

 75%|███████▌  | 46/61 [01:08<00:23,  1.58s/it]

Number of matches 21264
Number of matches After Lowe's Ratio 3827
Number of Robust matches 2411

 77%|███████▋  | 47/61 [01:10<00:22,  1.59s/it]

Number of matches 20833
Number of matches After Lowe's Ratio 3481
Number of Robust matches 2485

 79%|███████▊  | 48/61 [01:11<00:19,  1.53s/it]

Number of matches 18699
Number of matches After Lowe's Ratio 2089
Number of Robust matches 1382

 80%|███████▉  | 49/61 [01:13<00:17,  1.45s/it]

Number of matches 17733
Number of matches After Lowe's Ratio 3765
Number of Robust matches 3068

 82%|████████  | 50/61 [01:14<00:15,  1.38s/it]

Number of matches 18293
Number of matches After Lowe's Ratio 3611
Number of Robust matches 2860

 84%|████████▏ | 51/61 [01:15<00:13,  1.36s/it]

Number of matches 16473
Number of matches After Lowe's Ratio 2122
Number of Robust matches 1500

 85%|████████▎ | 52/61 [01:17<00:12,  1.39s/it]

Number of matches 17759
Number of matches After Lowe's Ratio 2191
Number of Robust matches 1598

 87%|████████▍ | 53/61 [01:18<00:10,  1.37s/it]

Number of matches 18253
Number of matches After Lowe's Ratio 2986
Number of Robust matches 2069

 89%|████████▌ | 54/61 [01:20<00:09,  1.41s/it]

Number of matches 18717
Number of matches After Lowe's Ratio 1913
Number of Robust matches 1190
```

```
 90%|█████████ | 55/61 [01:21<00:08,  1.36s/it]

Number of matches 18943
Number of matches After Lowe's Ratio 2424
Number of Robust matches 1617


 92%|█████████ | 56/61 [01:22<00:06,  1.36s/it]

Number of matches 18446
Number of matches After Lowe's Ratio 2199
Number of Robust matches 1186


 93%|█████████ | 57/61 [01:23<00:05,  1.34s/it]

Number of matches 19154
Number of matches After Lowe's Ratio 2713
Number of Robust matches 1497


 95%|█████████ | 58/61 [01:25<00:04,  1.34s/it]

Number of matches 20674
Number of matches After Lowe's Ratio 1787
Number of Robust matches 741


 97%|█████████ | 59/61 [01:26<00:02,  1.37s/it]

Number of matches 20317
Number of matches After Lowe's Ratio 2086
Number of Robust matches 821


 98%|█████████ | 60/61 [01:28<00:01,  1.47s/it]
  0%|          | 0/39 [00:00<?, ?it/s]

Number of matches 17535
Number of matches After Lowe's Ratio 741
Number of Robust matches 190


  3%|▎         | 1/39 [00:01<00:51,  1.36s/it]

Number of matches 20771
Number of matches After Lowe's Ratio 2615
Number of Robust matches 1992


  5%|▌         | 2/39 [00:03<00:57,  1.55s/it]

Number of matches 18297
Number of matches After Lowe's Ratio 2785
Number of Robust matches 1853


  8%|▊         | 3/39 [00:04<00:49,  1.38s/it]

Number of matches 15660
Number of matches After Lowe's Ratio 1352
Number of Robust matches 906


 10%|█         | 4/39 [00:05<00:43,  1.25s/it]

Number of matches 19968
```

Number of matches After Lowe's Ratio 627
Number of Robust matches 221

13%|▉ | 5/39 [00:06<00:42, 1.26s/it]

Number of matches 15728
Number of matches After Lowe's Ratio 2084
Number of Robust matches 1430

15%|▉ | 6/39 [00:07<00:40, 1.23s/it]

Number of matches 21692
Number of matches After Lowe's Ratio 1756
Number of Robust matches 1078

18%|▉ | 7/39 [00:09<00:42, 1.32s/it]

Number of matches 21865
Number of matches After Lowe's Ratio 3688
Number of Robust matches 2490

21%|▉ | 8/39 [00:10<00:43, 1.39s/it]

Number of matches 21455
Number of matches After Lowe's Ratio 5106
Number of Robust matches 4097

23%|▉ | 9/39 [00:12<00:42, 1.41s/it]

Number of matches 19571
Number of matches After Lowe's Ratio 3983
Number of Robust matches 3004

26%|▉ | 10/39 [00:13<00:43, 1.51s/it]

Number of matches 20134
Number of matches After Lowe's Ratio 3928
Number of Robust matches 3192

28%|▉ | 11/39 [00:15<00:41, 1.47s/it]

Number of matches 21099
Number of matches After Lowe's Ratio 2802
Number of Robust matches 2104

31%|▉ | 12/39 [00:16<00:40, 1.48s/it]

Number of matches 22136
Number of matches After Lowe's Ratio 3571
Number of Robust matches 2559

33%|▉ | 13/39 [00:18<00:40, 1.55s/it]

Number of matches 23198
Number of matches After Lowe's Ratio 2998
Number of Robust matches 1689

```
 36%|███       | 14/39 [00:20<00:39,  1.59s/it]
Number of matches 24310
Number of matches After Lowe's Ratio 2989
Number of Robust matches 1678

 38%|███▊      | 15/39 [00:22<00:42,  1.79s/it]
Number of matches 24654
Number of matches After Lowe's Ratio 3203
Number of Robust matches 1873

 41%|████      | 16/39 [00:24<00:41,  1.82s/it]
Number of matches 22984
Number of matches After Lowe's Ratio 3159
Number of Robust matches 1536

 44%|████▎     | 17/39 [00:26<00:40,  1.83s/it]
Number of matches 21716
Number of matches After Lowe's Ratio 2698
Number of Robust matches 1321

 46%|████▌     | 18/39 [00:27<00:36,  1.73s/it]
Number of matches 22411
Number of matches After Lowe's Ratio 3359
Number of Robust matches 1664

 49%|████▊     | 19/39 [00:29<00:33,  1.69s/it]
Number of matches 20504
Number of matches After Lowe's Ratio 2730
Number of Robust matches 1153

 51%|█████     | 20/39 [00:30<00:30,  1.60s/it]
Number of matches 20204
Number of matches After Lowe's Ratio 2682
Number of Robust matches 1166

 54%|█████▍    | 21/39 [00:32<00:27,  1.53s/it]
Number of matches 20233
Number of matches After Lowe's Ratio 2150
Number of Robust matches 1240

 56%|█████▋    | 22/39 [00:33<00:26,  1.55s/it]
Number of matches 27287
Number of matches After Lowe's Ratio 841
Number of Robust matches 223

 59%|█████▉    | 23/39 [00:35<00:28,  1.77s/it]
```

```
Number of matches 25609
Number of matches After Lowe's Ratio 1271
Number of Robust matches 396
```

```
 62%|██████    | 24/39 [00:37<00:27,  1.84s/it]
```

```
Number of matches 29338
Number of matches After Lowe's Ratio 476
Number of Robust matches 5
```

```
 64%|██████    | 25/39 [00:40<00:27,  1.94s/it]
```

```
Number of matches 24561
Number of matches After Lowe's Ratio 1210
Number of Robust matches 434
```

```
 67%|██████    | 26/39 [00:41<00:24,  1.91s/it]
```

```
Number of matches 22164
Number of matches After Lowe's Ratio 2286
Number of Robust matches 1018
```

```
 69%|██████    | 27/39 [00:43<00:21,  1.80s/it]
```

```
Number of matches 20348
Number of matches After Lowe's Ratio 2227
Number of Robust matches 880
```

```
 72%|███████   | 28/39 [00:44<00:18,  1.67s/it]
```

```
Number of matches 19519
Number of matches After Lowe's Ratio 1929
Number of Robust matches 878
```

```
 74%|███████   | 29/39 [00:46<00:16,  1.61s/it]
```

```
Number of matches 20911
Number of matches After Lowe's Ratio 1985
Number of Robust matches 672
```

```
 77%|███████   | 30/39 [00:47<00:14,  1.62s/it]
```

```
Number of matches 20565
Number of matches After Lowe's Ratio 1796
Number of Robust matches 670
```

```
 79%|███████   | 31/39 [00:49<00:12,  1.56s/it]
```

```
Number of matches 20347
Number of matches After Lowe's Ratio 3679
Number of Robust matches 1511
```

```
 82%|████████  | 32/39 [00:50<00:10,  1.52s/it]
```

```
Number of matches 22441
Number of matches After Lowe's Ratio 1722
Number of Robust matches 831
```

```
 85%|████████  | 33/39 [00:52<00:09,  1.62s/it]
```

```
Number of matches 21870
Number of matches After Lowe's Ratio 3196
Number of Robust matches 1672
```

```
 87%|████████  | 34/39 [00:54<00:08,  1.70s/it]
```

```
Number of matches 20671
Number of matches After Lowe's Ratio 2418
Number of Robust matches 1285
```

```
 90%|████████  | 35/39 [00:56<00:06,  1.63s/it]
```

```
Number of matches 18732
Number of matches After Lowe's Ratio 2370
Number of Robust matches 1561
```

```
 92%|████████  | 36/39 [00:57<00:04,  1.55s/it]
```

```
Number of matches 18770
Number of matches After Lowe's Ratio 1788
Number of Robust matches 1405
```

```
 95%|████████  | 37/39 [00:58<00:02,  1.48s/it]
```

```
Number of matches 18471
Number of matches After Lowe's Ratio 1840
Number of Robust matches 1247
```

```
 97%|████████  | 38/39 [00:59<00:01,  1.58s/it]
```

```
Number of matches 17991
Number of matches After Lowe's Ratio 2130
Number of Robust matches 1442
```

In [30]:

```
H_left_kaze = []
H_right_kaze = []

num_matches_kaze = []
num_good_matches_kaze = []

for j in tqdm(range(len(images_left))):
    if j==len(images_left)-1:
        break

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_kaze[j:j+2][::-1],points_all_left_kaze[j:j+2][::-1],descriptors_all_left_kaze[j:j+2][::
-1])
    H_left_kaze.append(H_a)
    num_matches_kaze.append(matches)
    num_good_matches_kaze.append(gd_matches)

for j in tqdm(range(len(images_right))):
    if j==len(images_right)-1:
        break
```

```
    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_kaze[j:j+2][::-1],points_all_right_kaze[j:j+2][::-1],descriptors_all_right_kaze[j:j+2
][::-1])
    H_right_kaze.append(H_a)
    num_matches_kaze.append(matches)
    num_good_matches_kaze.append(gd_matches)
```

```
  2%|▏         | 1/61 [00:01<01:14,  1.24s/it]
```

```
Number of matches 17737
Number of matches After Lowe's Ratio 2153
Number of Robust matches 884
```

```
  3%|▎         | 2/61 [00:02<01:18,  1.33s/it]
```

```
Number of matches 23066
Number of matches After Lowe's Ratio 2015
Number of Robust matches 844
```

```
  5%|▍         | 3/61 [00:04<01:27,  1.52s/it]
```

```
Number of matches 20398
Number of matches After Lowe's Ratio 673
Number of Robust matches 157
```

```
  7%|▋         | 4/61 [00:06<01:36,  1.69s/it]
```

```
Number of matches 19469
Number of matches After Lowe's Ratio 5120
Number of Robust matches 2846
```

```
  8%|▊         | 5/61 [00:07<01:30,  1.61s/it]
```

```
Number of matches 20021
Number of matches After Lowe's Ratio 5415
Number of Robust matches 3060
```

```
 10%|▉         | 6/61 [00:09<01:27,  1.58s/it]
```

```
Number of matches 20426
Number of matches After Lowe's Ratio 5271
Number of Robust matches 2740
```

```
 11%|█         | 7/61 [00:10<01:25,  1.59s/it]
```

```
Number of matches 22778
Number of matches After Lowe's Ratio 5833
Number of Robust matches 3237
```

```
 13%|█▏        | 8/61 [00:12<01:28,  1.66s/it]
```

```
Number of matches 17408
Number of matches After Lowe's Ratio 2987
Number of Robust matches 1432
```

```
 15%|█▍        | 9/61 [00:14<01:21,  1.57s/it]
```

```
Number of matches 23670
Number of matches After Lowe's Ratio 4731
Number of Robust matches 3021
```

Number of Robust matches 3021

16%|▉ | 10/61 [00:15<01:23, 1.63s/it]

Number of matches 18203
Number of matches After Lowe's Ratio 2672
Number of Robust matches 1699

18%|▉ | 11/61 [00:17<01:22, 1.65s/it]

Number of matches 22285
Number of matches After Lowe's Ratio 5374
Number of Robust matches 3748

20%|▉ | 12/61 [00:19<01:23, 1.71s/it]

Number of matches 22018
Number of matches After Lowe's Ratio 6566
Number of Robust matches 4572

21%|▉ | 13/61 [00:21<01:23, 1.74s/it]

Number of matches 24330
Number of matches After Lowe's Ratio 6268
Number of Robust matches 4492

23%|▉ | 14/61 [00:23<01:24, 1.81s/it]

Number of matches 24904
Number of matches After Lowe's Ratio 9139
Number of Robust matches 7492

25%|▉ | 15/61 [00:25<01:27, 1.89s/it]

Number of matches 23410
Number of matches After Lowe's Ratio 6898
Number of Robust matches 5252

26%|▉ | 16/61 [00:27<01:35, 2.12s/it]

Number of matches 21871
Number of matches After Lowe's Ratio 7176
Number of Robust matches 5281

28%|▉ | 17/61 [00:29<01:27, 1.99s/it]

Number of matches 21387
Number of matches After Lowe's Ratio 6375
Number of Robust matches 4703

30%|▉ | 18/61 [00:31<01:20, 1.88s/it]

Number of matches 21095
Number of matches After Lowe's Ratio 7142
Number of Robust matches 5618

31%|▉ | 19/61 [00:33<01:17, 1.84s/it]

31%|███ | 19/61 [00:32<01:17, 1.84s/it]

```
Number of matches 21423
Number of matches After Lowe's Ratio 8125
Number of Robust matches 5788
```

33%|███ | 20/61 [00:34<01:12, 1.78s/it]

```
Number of matches 20665
Number of matches After Lowe's Ratio 6707
Number of Robust matches 4596
```

34%|███ | 21/61 [00:36<01:08, 1.72s/it]

```
Number of matches 21776
Number of matches After Lowe's Ratio 5926
Number of Robust matches 3911
```

36%|███ | 22/61 [00:37<01:06, 1.70s/it]

```
Number of matches 21075
Number of matches After Lowe's Ratio 5783
Number of Robust matches 3797
```

38%|███ | 23/61 [00:39<01:08, 1.80s/it]

```
Number of matches 22361
Number of matches After Lowe's Ratio 5760
Number of Robust matches 3885
```

39%|███ | 24/61 [00:41<01:05, 1.78s/it]

```
Number of matches 21739
Number of matches After Lowe's Ratio 4969
Number of Robust matches 3112
```

41%|███ | 25/61 [00:43<01:03, 1.75s/it]

```
Number of matches 24424
Number of matches After Lowe's Ratio 4504
Number of Robust matches 2373
```

43%|███ | 26/61 [00:45<01:02, 1.79s/it]

```
Number of matches 21469
Number of matches After Lowe's Ratio 4729
Number of Robust matches 2294
```

44%|███ | 27/61 [00:47<01:01, 1.80s/it]

```
Number of matches 22552
Number of matches After Lowe's Ratio 5039
Number of Robust matches 2740
```

46%|███ | 28/61 [00:48<00:58, 1.78s/it]

```
Number of matches 21879
Number of matches After Lowe's Ratio 4678
```

```
Number of Robust matches 1842

 48%|████      | 29/61 [00:50<00:59,  1.84s/it]

Number of matches 25013
Number of matches After Lowe's Ratio 3112
Number of Robust matches 1320

 49%|████      | 30/61 [00:52<01:00,  1.95s/it]

Number of matches 24466
Number of matches After Lowe's Ratio 4458
Number of Robust matches 1894

 51%|█████     | 31/61 [00:54<00:58,  1.95s/it]

Number of matches 24798
Number of matches After Lowe's Ratio 2408
Number of Robust matches 1008

 52%|█████     | 32/61 [00:56<00:56,  1.94s/it]

Number of matches 21670
Number of matches After Lowe's Ratio 1168
Number of Robust matches 320

 54%|█████     | 33/61 [00:58<00:54,  1.93s/it]

Number of matches 21083
Number of matches After Lowe's Ratio 4260
Number of Robust matches 2042

 56%|█████     | 34/61 [01:01<00:55,  2.04s/it]

Number of matches 19041
Number of matches After Lowe's Ratio 4643
Number of Robust matches 2461

 57%|█████     | 35/61 [01:02<00:48,  1.86s/it]

Number of matches 21135
Number of matches After Lowe's Ratio 4234
Number of Robust matches 2354

 59%|█████     | 36/61 [01:04<00:45,  1.81s/it]

Number of matches 25378
Number of matches After Lowe's Ratio 5589
Number of Robust matches 2570

 61%|██████    | 37/61 [01:06<00:46,  1.92s/it]

Number of matches 28928
Number of matches After Lowe's Ratio 5217
Number of Robust matches 2032
```

62%|██████ | 38/61 [01:08<00:49, 2.14s/it]

```
Number of matches 31135
Number of matches After Lowe's Ratio 7080
Number of Robust matches 3503
```

64%|██████ | 39/61 [01:11<00:51, 2.34s/it]

```
Number of matches 28082
Number of matches After Lowe's Ratio 6718
Number of Robust matches 3074
```

66%|██████ | 40/61 [01:14<00:49, 2.35s/it]

```
Number of matches 24578
Number of matches After Lowe's Ratio 6478
Number of Robust matches 3274
```

67%|██████ | 41/61 [01:16<00:44, 2.24s/it]

```
Number of matches 22760
Number of matches After Lowe's Ratio 6537
Number of Robust matches 3891
```

69%|██████ | 42/61 [01:17<00:39, 2.09s/it]

```
Number of matches 21201
Number of matches After Lowe's Ratio 6226
Number of Robust matches 4159
```

70%|██████ | 43/61 [01:19<00:35, 1.95s/it]

```
Number of matches 21619
Number of matches After Lowe's Ratio 7157
Number of Robust matches 4747
```

72%|██████ | 44/61 [01:21<00:32, 1.91s/it]

```
Number of matches 23323
Number of matches After Lowe's Ratio 6371
Number of Robust matches 4326
```

74%|██████ | 45/61 [01:23<00:31, 1.97s/it]

```
Number of matches 24274
Number of matches After Lowe's Ratio 7451
Number of Robust matches 4387
```

75%|██████ | 46/61 [01:25<00:29, 1.95s/it]

```
Number of matches 23964
Number of matches After Lowe's Ratio 7824
Number of Robust matches 4400
```

77%|██████ | 47/61 [01:27<00:28, 2.01s/it]

```
Number of matches 23881
Number of matches After Lowe's Ratio 7555
```

```
Number of Robust matches 3797

 79%|███████▉  | 48/61 [01:29<00:25,  1.96s/it]

Number of matches 22006
Number of matches After Lowe's Ratio 4740
Number of Robust matches 3199

 80%|████████  | 49/61 [01:31<00:22,  1.88s/it]

Number of matches 21045
Number of matches After Lowe's Ratio 7830
Number of Robust matches 5902

 82%|████████▏ | 50/61 [01:33<00:21,  2.00s/it]

Number of matches 21574
Number of matches After Lowe's Ratio 7617
Number of Robust matches 5893

 84%|████████▎ | 51/61 [01:35<00:19,  1.99s/it]

Number of matches 19699
Number of matches After Lowe's Ratio 4799
Number of Robust matches 3379

 85%|████████▌ | 52/61 [01:36<00:16,  1.85s/it]

Number of matches 20924
Number of matches After Lowe's Ratio 5003
Number of Robust matches 3520

 87%|████████▋ | 53/61 [01:38<00:14,  1.79s/it]

Number of matches 21133
Number of matches After Lowe's Ratio 6936
Number of Robust matches 4490

 89%|████████▊ | 54/61 [01:40<00:12,  1.74s/it]

Number of matches 21286
Number of matches After Lowe's Ratio 4944
Number of Robust matches 3275

 90%|████████▉ | 55/61 [01:41<00:10,  1.74s/it]

Number of matches 20795
Number of matches After Lowe's Ratio 5577
Number of Robust matches 3780

 92%|████████▉ | 56/61 [01:43<00:08,  1.69s/it]

Number of matches 20754
Number of matches After Lowe's Ratio 4917
Number of Robust matches 2400
```

```
 93%|█████████ | 57/61 [01:45<00:06,  1.73s/it]

Number of matches 21466
Number of matches After Lowe's Ratio 6535
Number of Robust matches 3206


 95%|██████████ | 58/61 [01:46<00:05,  1.71s/it]

Number of matches 22210
Number of matches After Lowe's Ratio 4523
Number of Robust matches 1900


 97%|██████████ | 59/61 [01:48<00:03,  1.75s/it]

Number of matches 22050
Number of matches After Lowe's Ratio 5941
Number of Robust matches 2571


 98%|██████████ | 60/61 [01:50<00:01,  1.84s/it]
  0%|           | 0/39 [00:00<?, ?it/s]

Number of matches 19110
Number of matches After Lowe's Ratio 1849
Number of Robust matches 585


  3%|▎          | 1/39 [00:01<00:56,  1.50s/it]

Number of matches 22253
Number of matches After Lowe's Ratio 5306
Number of Robust matches 3151


  5%|▌          | 2/39 [00:03<00:59,  1.61s/it]

Number of matches 19990
Number of matches After Lowe's Ratio 5614
Number of Robust matches 3729


  8%|▊          | 3/39 [00:04<00:58,  1.62s/it]

Number of matches 17969
Number of matches After Lowe's Ratio 2805
Number of Robust matches 2069


 10%|█          | 4/39 [00:06<00:56,  1.61s/it]

Number of matches 21377
Number of matches After Lowe's Ratio 1788
Number of Robust matches 1022


 13%|█▎         | 5/39 [00:07<00:54,  1.59s/it]

Number of matches 18219
Number of matches After Lowe's Ratio 4636
Number of Robust matches 3034


 15%|█▌         | 6/39 [00:09<00:50,  1.54s/it]

Number of matches 22112
```

Number of matches 23113
Number of matches After Lowe's Ratio 3643
Number of Robust matches 2644

18%|▉ | 7/39 [00:11<00:53, 1.68s/it]

Number of matches 23306
Number of matches After Lowe's Ratio 8611
Number of Robust matches 6786

21%|▉ | 8/39 [00:13<00:53, 1.73s/it]

Number of matches 22231
Number of matches After Lowe's Ratio 8944
Number of Robust matches 6983

23%|▉ | 9/39 [00:15<00:56, 1.87s/it]

Number of matches 20707
Number of matches After Lowe's Ratio 6865
Number of Robust matches 5431

26%|▉ | 10/39 [00:17<00:53, 1.86s/it]

Number of matches 21002
Number of matches After Lowe's Ratio 6993
Number of Robust matches 5718

28%|▉ | 11/39 [00:18<00:51, 1.83s/it]

Number of matches 22557
Number of matches After Lowe's Ratio 5529
Number of Robust matches 4169

31%|▉ | 12/39 [00:20<00:48, 1.80s/it]

Number of matches 22744
Number of matches After Lowe's Ratio 6894
Number of Robust matches 5008

33%|▉ | 13/39 [00:22<00:46, 1.79s/it]

Number of matches 23731
Number of matches After Lowe's Ratio 6303
Number of Robust matches 3986

36%|▉ | 14/39 [00:24<00:45, 1.80s/it]

Number of matches 25368
Number of matches After Lowe's Ratio 7095
Number of Robust matches 3681

38%|▉ | 15/39 [00:26<00:45, 1.92s/it]

Number of matches 25661
Number of matches After Lowe's Ratio 7431
Number of Robust matches 3611

```
 41%|████      | 16/39 [00:28<00:46,  2.04s/it]
Number of matches 24425
Number of matches After Lowe's Ratio 7821
Number of Robust matches 3691

 44%|████      | 17/39 [00:30<00:43,  2.00s/it]
Number of matches 22841
Number of matches After Lowe's Ratio 6350
Number of Robust matches 2954

 46%|████      | 18/39 [00:32<00:41,  1.98s/it]
Number of matches 22352
Number of matches After Lowe's Ratio 7227
Number of Robust matches 3017

 49%|████      | 19/39 [00:34<00:38,  1.91s/it]
Number of matches 21771
Number of matches After Lowe's Ratio 5762
Number of Robust matches 2311

 51%|████      | 20/39 [00:36<00:34,  1.83s/it]
Number of matches 20959
Number of matches After Lowe's Ratio 5515
Number of Robust matches 2484

 54%|████      | 21/39 [00:37<00:31,  1.76s/it]
Number of matches 20882
Number of matches After Lowe's Ratio 4427
Number of Robust matches 2367

 56%|████      | 22/39 [00:39<00:31,  1.85s/it]
Number of matches 28555
Number of matches After Lowe's Ratio 2126
Number of Robust matches 856

 59%|████      | 23/39 [00:42<00:31,  2.00s/it]
Number of matches 26455
Number of matches After Lowe's Ratio 4168
Number of Robust matches 1741

 62%|████      | 24/39 [00:44<00:30,  2.06s/it]
Number of matches 31041
Number of matches After Lowe's Ratio 520
Number of Robust matches 48

 64%|████      | 25/39 [00:46<00:31,  2.23s/it]
```

```
Number of matches 25532
Number of matches After Lowe's Ratio 3385
Number of Robust matches 1232


 67%|██████    | 26/39 [00:49<00:31,  2.41s/it]

Number of matches 23237
Number of matches After Lowe's Ratio 5561
Number of Robust matches 2336


 69%|██████    | 27/39 [00:51<00:26,  2.21s/it]

Number of matches 21219
Number of matches After Lowe's Ratio 4952
Number of Robust matches 2232


 72%|███████   | 28/39 [00:53<00:22,  2.07s/it]

Number of matches 20480
Number of matches After Lowe's Ratio 4331
Number of Robust matches 1925


 74%|███████   | 29/39 [00:54<00:19,  1.92s/it]

Number of matches 22293
Number of matches After Lowe's Ratio 4794
Number of Robust matches 1772


 77%|███████   | 30/39 [00:56<00:16,  1.85s/it]

Number of matches 21755
Number of matches After Lowe's Ratio 4621
Number of Robust matches 1832


 79%|███████   | 31/39 [00:58<00:14,  1.80s/it]

Number of matches 22020
Number of matches After Lowe's Ratio 7709
Number of Robust matches 3095


 82%|████████  | 32/39 [01:00<00:12,  1.85s/it]

Number of matches 23245
Number of matches After Lowe's Ratio 4220
Number of Robust matches 1685


 85%|████████  | 33/39 [01:01<00:11,  1.86s/it]

Number of matches 22554
Number of matches After Lowe's Ratio 7173
Number of Robust matches 4009


 87%|████████  | 34/39 [01:03<00:09,  1.82s/it]

Number of matches 21359
Number of matches After Lowe's Ratio 5487
Number of Robust matches 2907
```

```
 90%|████████▉ | 35/39 [01:05<00:06,  1.75s/it]

Number of matches 20079
Number of matches After Lowe's Ratio 4650
Number of Robust matches 2916


 92%|█████████▏ | 36/39 [01:06<00:05,  1.72s/it]

Number of matches 20334
Number of matches After Lowe's Ratio 3756
Number of Robust matches 2790


 95%|█████████▍ | 37/39 [01:08<00:03,  1.67s/it]

Number of matches 20129
Number of matches After Lowe's Ratio 4689
Number of Robust matches 3470


 97%|█████████▋ | 38/39 [01:09<00:01,  1.84s/it]

Number of matches 19798
Number of matches After Lowe's Ratio 4601
Number of Robust matches 3417
```

In [21]:

```
def warpnImages(images_left, images_right,H_left,H_right):
    #img1-centre,img2-left,img3-right

    h, w = images_left[0].shape[:2]

    pts_left = []
    pts_right = []

    pts_centre = np.float32([[0, 0], [0, h], [w, h], [w, 0]]).reshape(-1, 1, 2)

    for j in range(len(H_left)):
      pts = np.float32([[0, 0], [0, h], [w, h], [w, 0]]).reshape(-1, 1, 2)
      pts_left.append(pts)

    for j in range(len(H_right)):
      pts = np.float32([[0, 0], [0, h], [w, h], [w, 0]]).reshape(-1, 1, 2)
      pts_right.append(pts)

    pts_left_transformed=[]
    pts_right_transformed=[]

    for j,pts in enumerate(pts_left):
      if j==0:
        H_trans = H_left[j]
      else:
        H_trans = H_trans@H_left[j]
      pts_ = cv2.perspectiveTransform(pts, H_trans)
      pts_left_transformed.append(pts_)

    for j,pts in enumerate(pts_right):
      if j==0:
        H_trans = H_right[j]
      else:
        H_trans = H_trans@H_right[j]
      pts_ = cv2.perspectiveTransform(pts, H_trans)
      pts_right_transformed.append(pts_)
```

```
    print('Step1:Done')


    #pts = np.concatenate((pts1, pts2_), axis=0)

    pts_concat = np.concatenate((pts_centre,np.concatenate(np.array(pts_left_transformed
),axis=0),np.concatenate(np.array(pts_right_transformed),axis=0)), axis=0)

    [xmin, ymin] = np.int32(pts_concat.min(axis=0).ravel() - 0.5)
    [xmax, ymax] = np.int32(pts_concat.max(axis=0).ravel() + 0.5)
    t = [-xmin, -ymin]
    Ht = np.array([[1, 0, t[0]], [0, 1, t[1]], [0, 0, 1]])  # translate

    print('Step2:Done')


    return xmax,xmin,ymax,ymin,t,h,w,Ht
```

In [22]:

```
def final_steps_left_union(images_left,H_left,xmax,xmin,ymax,ymin,t,h,w,Ht):
    for j,H in enumerate(H_left):
        if j==  0:
            H_trans = Ht@H
        else:
            H_trans = H_trans@H
        result =  cv2.warpPerspective(images_left[j+1],H_trans,(xmax-xmin,ymax-ymin))
        warp_img_init_curr = result

        if j == 0:
            result[t[1]:h+t[1],t[0]:w+t[0]] = images_left[0]
            warp_img_init_prev = result
            continue
        black_pixels = np.where((warp_img_init_prev[:,:,0]==0)&(warp_img_init_prev[:,:,1
]==0)&(warp_img_init_prev[:,:,2]==0))
        warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('step31:Done')
    return warp_img_init_prev

def final_step_right_union(warp_img_prev,images_right,H_right,xmax,xmin,ymax,ymin,t,h,w,
Ht):
    for j,H in enumerate(H_right):
        if j==  0:
            H_trans = Ht@H
        else:
            H_trans = H_trans@H
        result =  cv2.warpPerspective(images_right[j+1],H_trans,(xmax-xmin,ymax-ymin))
        warp_img_init_curr = result



        black_pixels = np.where((warp_img_prev[:,:,0]==0)&(warp_img_prev[:,:,1]==0)&(war
p_img_prev[:,:,2]==0))
        warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('step32:Done')
    return warp_img_prev
```

In [24]:

```
xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_agast,H_right_agast)
```

```
Step1:Done
Step2:Done
```

In [25]:

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_agast,xmax,xmin
```

```
,ymax,ymin,t,h,w,Ht)
```

```
step31:Done
```

In [26]:

```
warp_imgs_all_agast = final_step_right_union(warp_imgs_left,images_right_bgr_no_enhance,H
_right_agast,xmax,xmin,ymax,ymin,t,h,w,Ht)
```

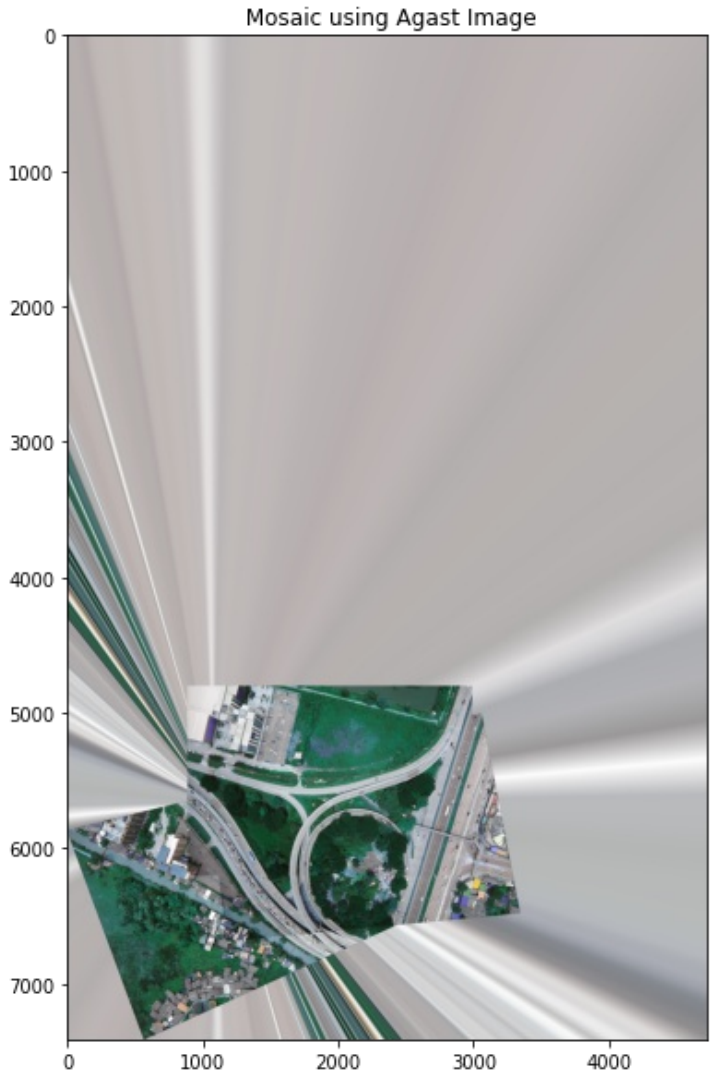
```
step32:Done
```

In [27]:

```
plt.figure(figsize=(20,10))
plt.imshow(warp_imgs_all_agast)
plt.title(' Mosaic using Agast Image')
```

Out[27]:

```
Text(0.5, 1.0, ' Mosaic using Agast Image')
```



In [32]:

```
omax,omin,umax,umin,T,H,W,HT = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_kaze,H_right_kaze)
```

```
Step1:Done
Step2:Done
```

In [33]:

```
warp_img = final_steps_left_union(images_left_bgr_no_enhance,H_left_kaze,omax,omin,umax,u
min,T,H,W,HT)
```

```
step31:Done
```

In [35]:

```
warp_imgs_all_kaze = final_step_right_union(warp_img,images_right_bgr_no_enhance,H_right_
kaze,omax,omin,umax,umin,T,H,W,HT)
```

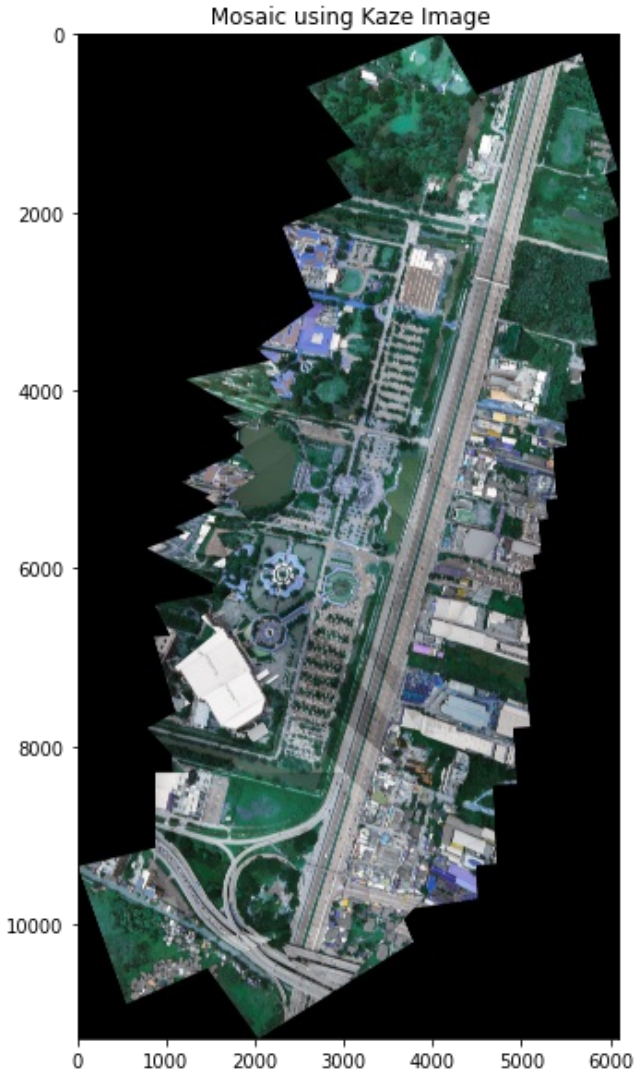
```
step32:Done
```

In [36]:

```
plt.figure(figsize=(20,10))
plt.imshow(warp_imgs_all_kaze)
plt.title(' Mosaic using Kaze Image')
```

Out[36]:

```
Text(0.5, 1.0, ' Mosaic using Kaze Image')
```



In [23]:

```
mmax,mmin,nmax,nmin,d,e,f,g = warpnImages(images_left_bgr_no_enhance, images_right_bgr_n
o_enhance,H_left_sift,H_right_sift)
```

```
Step1:Done
Step2:Done
```

In [24]:

```
warp_imgs_sift = final_steps_left_union(images_left_bgr_no_enhance,H_left_sift,mmax,mmin,
nmax,nmin,d,e,f,g)
```

```
step31:Done
```

In [25]:

```
warp_imgs_all_sift = final_step_right_union(warp_imgs_sift,images_right_bgr_no_enhance,H_
right_sift,mmax,mmin,nmax,nmin,d,e,f,g)
```

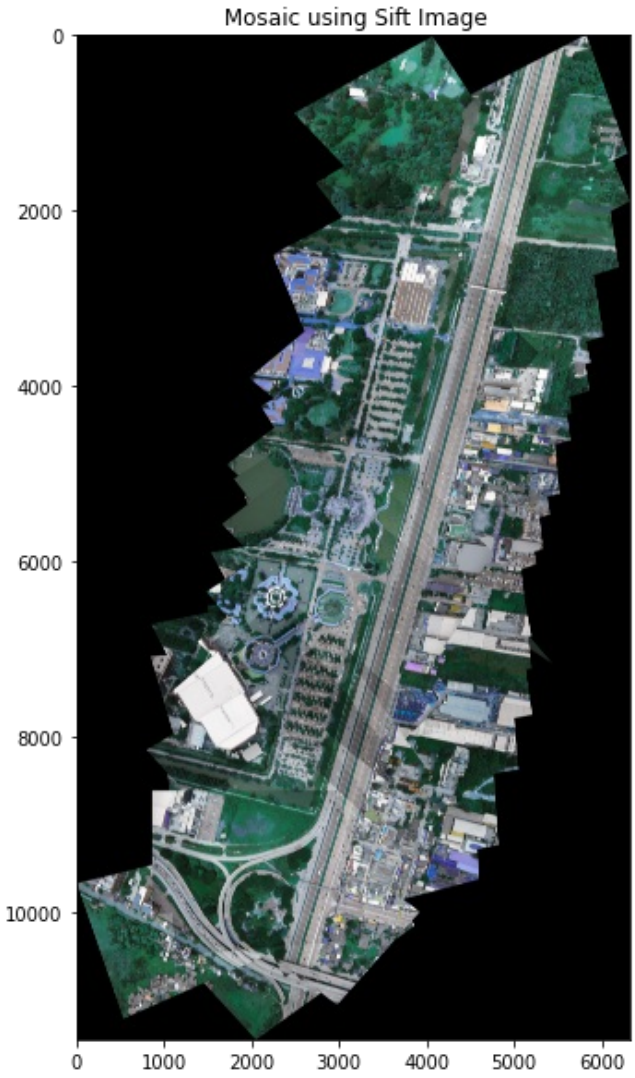
```
step32:Done
```

In [26]:

```
plt.figure(figsize=(20,10))
plt.imshow(warp_imgs_all_sift)
plt.title(' Mosaic using Sift Image')
```

Out[26]:

```
Text(0.5, 1.0, ' Mosaic using Sift Image')
```



In [30]:

```
omax,omin,umax,umin,T,H,W,HT = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_surf,H_right_surf)
```

```
Step1:Done
Step2:Done
```

In [31]:

```
warp_img_surf = final_steps_left_union(images_left_bgr_no_enhance,H_left_surf,omax,omin,u
max,umin,T,H,W,HT)
```

```
step31:Done
```

In [32]:

```
warp_imgs_all_surf = final_step_right_union(warp_img_surf,images_right_bgr_no_enhance,H_r
ight_surf,omax,omin,umax,umin,T,H,W,HT)
```

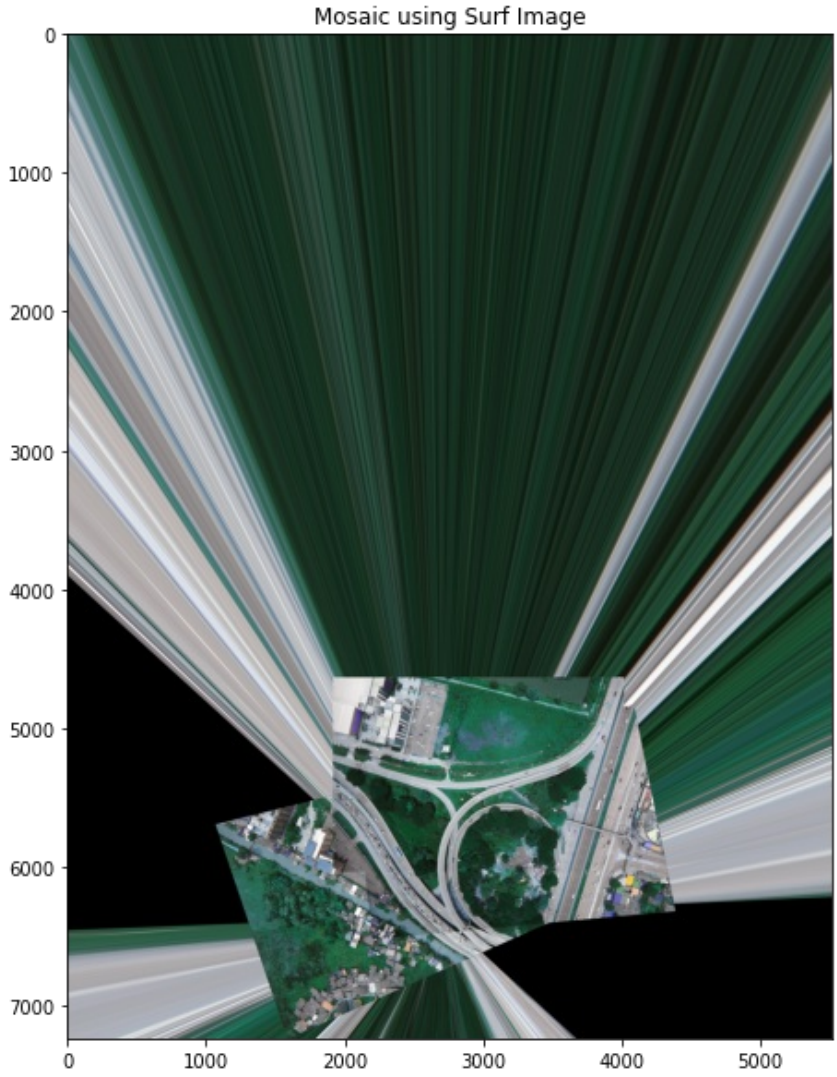
```
step32:Done
```

In [33]:

```
plt.figure(figsize=(20,10))
plt.imshow(warp_imgs_all_surf)
plt.title('Mosaic using Surf Image')
```

Out[33]:

```
Text(0.5, 1.0, 'Mosaic using Surf Image')
```



In [23]:

```
omax,omin,umax,umin,T,H,W,HT = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_akaze,H_right_akaze)
```

```
Step1:Done
Step2:Done
```

In [24]:

```
warp_img_akaze = final_steps_left_union(images_left_bgr_no_enhance,H_left_akaze,omax,omin
,umax,umin,T,H,W,HT)
```

```
step31:Done
```

In [25]:

```
warp_imgs_all_akaze = final_step_right_union(warp_img_akaze,images_right_bgr_no_enhance,H
_right_akaze,omax,omin,umax,umin,T,H,W,HT)
```

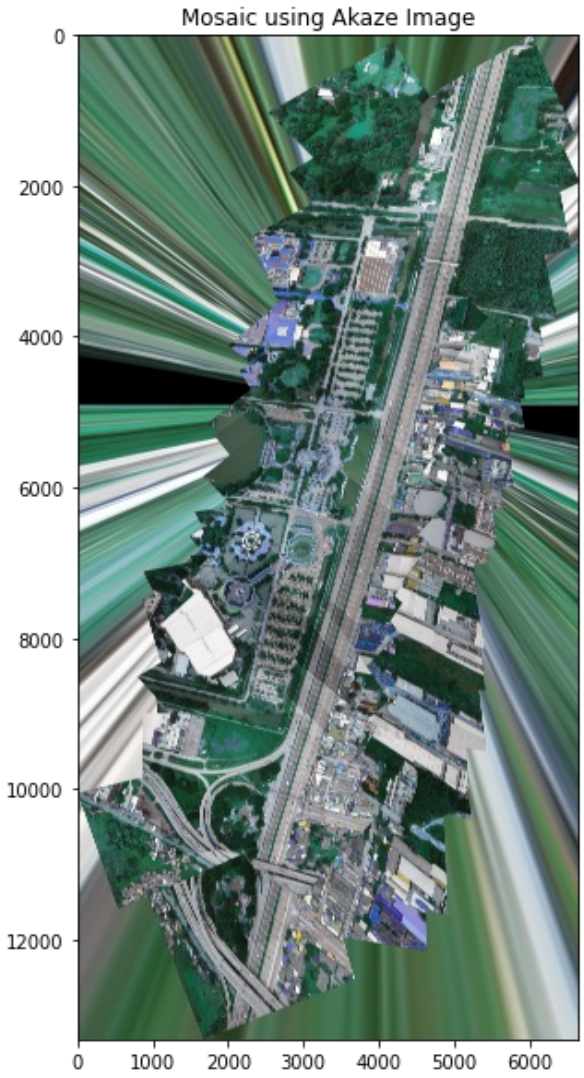
```
step32:Done
```

In [26]:

```
plt.figure(figsize=(20,10))
plt.imshow(warp_imgs_all_akaze)
plt.title('Mosaic using Akaze Image')
```

Out[26]:

```
Text(0.5, 1.0, 'Mosaic using Akaze Image')
```



In [23]:

```
amax,amin,zmax,zmin,d,i,q,ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_daisy,H_right_daisy)
```

```
Step1:Done
Step2:Done
```

In [24]:

```
warp_image_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_daisy,amax,ami
n,zmax,zmin,d,i,q,ht)
```

```
step31:Done
```

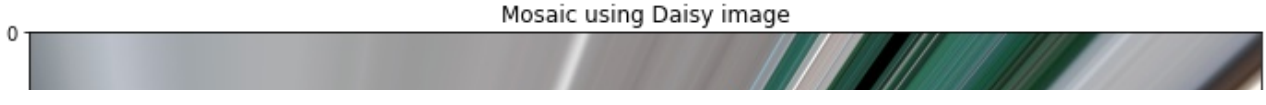
In [25]:

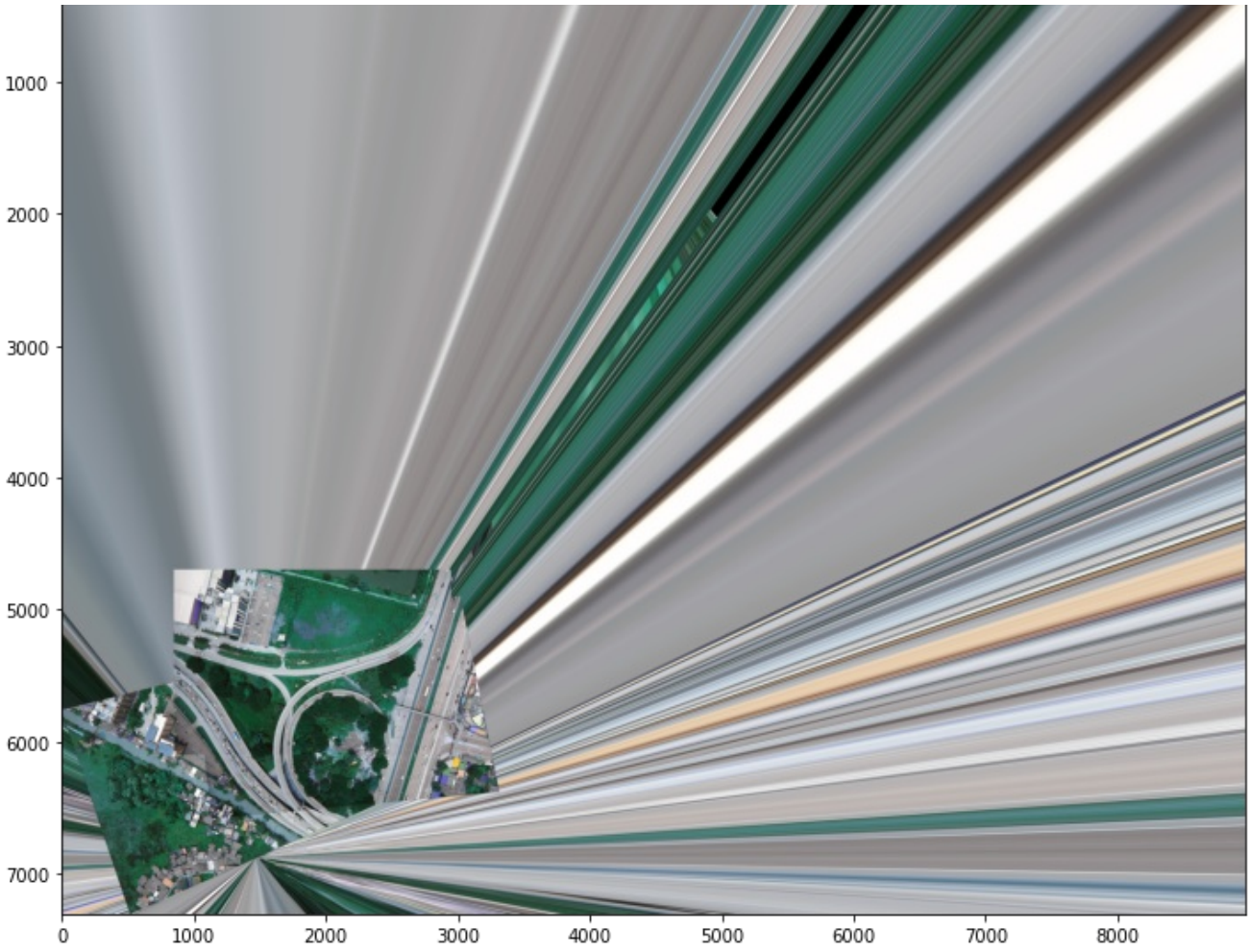
```
warp_imgs_all_daisy = final_step_right_union(warp_image_left,images_right_bgr_no_enhance,
H_right_daisy,amax,amin,zmax,zmin,d,i,q,ht)
```

```
step32:Done
```

In [26]:

```
plt.figure(figsize=(20,10))
plt.imshow(warp_imgs_all_daisy)
plt.title('Mosaic using Daisy image')
plt.imsave('Mosaic using Daisy Image.jpg',warp_imgs_all_daisy)
```




1000
2000
3000
4000
5000
6000
7000
0
1000
2000
3000
4000
5000
6000
7000
8000

In [ ]: