```
import numpy as np
import cv2
import scipy.io
import os
from numpy.linalg import norm
from matplotlib import pyplot as plt
from numpy.linalg import det
from numpy.linalg import inv
from scipy.linalg import rq
from numpy.linalg import svd
import matplotlib.pyplot as plt
import numpy as np
import math
import random
import sys
from scipy import ndimage, spatial
from tqdm.notebook import tqdm, trange

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
```

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```
import matplotlib.pyplot as plt
import time
import os
import copy
import sklearn.svm
import cv2
from matplotlib import pyplot as plt
import numpy as np
from os.path import exists
import pandas as pd
import PIL
import random
from google.colab import drive
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


from google.colab import drive

# This will prompt for authorization.
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

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

```
Requirement already satisfied: opencv-python==3.4.2.17 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: numpy>=1.14.5 in /usr/local/lib/python3.7/dist-packages (
Requirement already satisfied: opencv-contrib-python==3.4.2.17 in /usr/local/lib/python3
Requirement already satisfied: numpy>=1.14.5 in /usr/local/lib/python3.7/dist-packages (
```

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

        self.img = img
        self.position = position

inlier_matchset = []
def features_matching(a,keypointlength,threshold):
```

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```
  for j in range(0,keypointlength):
    #For a descriptor fa in Ia, take the two closest descriptors fb1 and fb2 in Ib
    x=a[j]
    listx=x.tolist()
    x.sort()
    minval1=x[0]                                # min
    minval2=x[1]                                # 2nd min
    itemindex1 = listx.index(minval1)           #index of min val
    itemindex2 = listx.index(minval2)           #index of second min value
    ratio=minval1/minval2                       #Ratio Test

    if ratio<threshold:
      #Low distance ratio: fb1 can be a good match
      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,ind
```

```
def compute_Homography(im1_pts,im2_pts):
  """
  im1_pts and im2_pts are 2×n matrices with
  4 point correspondences from the two images
  """
  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] # First row
    row2 = [0, 0, 0, a_x, a_y, 1, -b_y*a_x, -b_y*a_y, -b_y] # Second row

    # place the rows in the matrix
    A[a_index] = row1
    A[a_index+1] = row2

    a_index += 2

  U, s, Vt = np.linalg.svd(A)

  #s is a 1-D array of singular values sorted in descending order
```

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```
  #Vt[-1].reshape(3,3) # take the last row of the Vt matrix
  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 get_inliers(f1, f2, matches, H, RANSACthresh):

  inlier_indices = []
  for i in range(len(matches)):
    queryInd = matches[i].queryIdx
    trainInd = matches[i].trainIdx

    #queryInd = matches[i][0]
    #trainInd = matches[i][1]
```

```
      #trainInd = matches[i][1]

      queryPoint = np.array([f1[queryInd].pt[0],  f1[queryInd].pt[1], 1]).T
      trans_query = H.dot(queryPoint)


      comp1 = [trans_query[0]/trans_query[2], trans_query[1]/trans_query[2]] # normalize with r
      comp2 = np.array(f2[trainInd].pt)[:2]


      if(np.linalg.norm(comp1-comp2) <= RANSACthresh): # check against threshold
        inlier_indices.append(i)
    return inlier_indices


def RANSAC_alg(f1, f2, matches, nRANSAC, RANSACthresh):


    minMatches = 4
    nBest = 0
    best_inliers = []
    H_estimate = np.eye(3,3)
    global inlier_matchset
    inlier_matchset=[]
    for iteration in range(nRANSAC):

        #Choose a minimal set of feature matches.
```



```
          m = matchSample[i]
          im1_pts[i] = f1[m.queryIdx].pt
          im2_pts[i] = f2[m.trainIdx].pt
          #im1_pts[i] = f1[m[0]].pt
          #im2_pts[i] = f2[m[1]].pt

        H_estimate=compute_Homography(im1_pts,im2_pts)


        # Calculate the inliers for the H
        inliers = get_inliers(f1, f2, matches, H_estimate, RANSACthresh)

        # if the number of inliers is higher than previous iterations, update the best estima
        if len(inliers) > nBest:
            nBest= len(inliers)
            best_inliers = inliers

    print("Number of best inliers",len(best_inliers))
    for i in range(len(best_inliers)):
```

```
        inlier_matchset.append(matches[best_inliers[i]])

    # compute a homography given this set of matches
    im1_pts=np.empty((len(best_inliers),2))
    im2_pts=np.empty((len(best_inliers),2))
    for i in range(0,len(best_inliers)):
      m = inlier_matchset[i]
      im1_pts[i] = f1[m.queryIdx].pt
      im2_pts[i] = f2[m.trainIdx].pt
      #im1_pts[i] = f1[m[0]].pt
      #im2_pts[i] = f2[m[1]].pt

    M=compute_Homography(im1_pts,im2_pts)
    return M, best_inliers


files_all=[]
for file in os.listdir("/content/drive/MyDrive/RGB-img/img"):
    if file.endswith(".JPG"):
      files_all.append(file)


files_all.sort()
folder_path = '/content/drive/MyDrive/RGB-img/img/'

centre_file = folder_path + files_all[15]
left_files_path_rev = []
```

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```
left_files_path = left_files_path_rev[::-1]

for file in files_all[50:100]:
  right_files_path.append(folder_path + file)


from PIL.ExifTags import TAGS
from PIL.ExifTags import GPSTAGS
from PIL import Image
def get_exif(filename):
    image = Image.open(filename)
    image.verify()
    return image._getexif()

def get_labeled_exif(exif):
    labeled = {}
    for (key, val) in exif.items():
        labeled[TAGS.get(key)] = val

    return labeled
```

```
def get_geotagging(exif):
    if not exif:
        raise ValueError("No EXIF metadata found")

    geotagging = {}
    for (idx, tag) in TAGS.items():
        if tag == 'GPSInfo':
            if idx not in exif:
                raise ValueError("No EXIF geotagging found")

            for (key, val) in GPSTAGS.items():
                if key in exif[idx]:
                    geotagging[val] = exif[idx][key]
    return geotagging

def get_decimal_from_dms(dms, ref):

    degrees = dms[0][0] / dms[0][1]
    minutes = dms[1][0] / dms[1][1] / 60.0
    seconds = dms[2][0] / dms[2][1] / 3600.0

    if ref in ['S', 'W']:
        degrees = -degrees
        minutes = -minutes
        seconds = -seconds
```

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```
                                                    ['GPSLatitudeRef'])

    lon = get_decimal_from_dms(geotags['GPSLongitude'], geotags['GPSLongitudeRef'])

    return (lat,lon)


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=0.20, fy=0.20, interpolation = cv2.INTER_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=0.20,fy=0.20, interpolation = cv2.INTER_CUBI
  images_right.append(cv2.cvtColor(right_img, cv2.COLOR_BGR2GRAY).astype('float32')/255.)
  images_right_bgr.append(right_img)
```

```
100%|██████████| 51/51 [00:57<00:00,  1.13s/it]
100%|██████████| 50/50 [00:56<00:00,  1.12s/it]
```

```
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=0.20, fy=0.20, interpolation = cv2.INTER_CUBIC
  images_left_bgr_no_enhance.append(left_img)
```

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interpolation = cv2.INTER_CUBI

```
100%|██████████| 51/51 [00:21<00:00,  2.42it/s]
100%|██████████| 50/50 [00:20<00:00,  2.45it/s]
```

```
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%|██████████| 51/51 [09:37<00:00, 11.32s/it]
       100%|██████████| 50/50 [09:44<00:00, 11.68s/it]


  #num_kps_sift = []
  #num_kps_brisk = []
  #num_kps_agast = []
  #num_kps_kaze = []
  #num_kps_akaze = []
  #num_kps_orb = []
  #num_kps_mser = []
  #num_kps_daisy = []
  num_kps_surfsift = []
  #num_kps_fast = []
  #num_kps_freak = []
  #num_kps_gftt = []
  #num_kps_star = []

  #for i in tqdm(keypoints_all_left_sift + keypoints_all_right_sift):
```



```
  #for j in tqdm(keypoints_all_left_brisk + keypoints_all_right_brisk):
    #num_kps_brisk.append(len(j))

  #for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):
    #num_kps_agast.append(len(j))

  #for j in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):
   # num_kps_kaze.append(len(j))

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

  #for j in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
    #num_kps_orb.append(len(j))

  #for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
   # num_kps_mser.append(len(j))

  #for j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
  #  num_kps_daisy.append(len(j))

  for j in tqdm(keypoints_all_left_surfsift + keypoints_all_right_surfsift):
```

```
    num_kps_surfsift.append(len(j))

  #for j in tqdm(keypoints_all_left_fast + keypoints_all_right_fast):
    #num_kps_fast.append(len(j))

  #for j in tqdm(keypoints_all_left_freak + keypoints_all_right_freak):
    #num_kps_freak.append(len(j))

  #for j in tqdm(keypoints_all_left_gftt + keypoints_all_right_gftt):
    #num_kps_gftt.append(len(j))

  #for j in tqdm(keypoints_all_left_star + keypoints_all_right_star):
    #num_kps_star.append(len(j))
```

```
100%|██████████| 101/101 [00:00<00:00, 241106.83it/s]
```

```
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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
    return H, inliers
```

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```
    # Estimate the homography between the matches using RANSAC
    H, inliers = cv2.findHomography(matched_pts1,
                                    matched_pts2,
                                    0)
    inliers = inliers.flatten()
    return H, inliers


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)
```

```
matches_lf1_lf = flann.knnMatch(lf1, lf, 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_1.append((m[0].trainIdx, m[0].queryIdx))
      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])
matches_idx = np.array([m.trainIdx for m in matches_4])
imm2_pts = np.array([keypts[1][idx].pt for idx in matches_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)):
```

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```
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, RANSACthresh=6)
'''



Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
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,fl
      displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

    return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


from functools import partial
from tqdm import tqdm
```

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View runtime logs

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
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_surfsi
```

```
    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left_surfsi
    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_right_surf
    H_right_surfsift.append(H_a)
    num_matches_surfsift.append(matches)
    num_good_matches_surfsift.append(gd_matches)
```

```
 55%|█████▌    | 28/51 [01:15<00:57,  2.50s/it]
Number of matches 14910
Number of matches After Lowe's Ratio 3089
Number of Robust matches 1550


 57%|█████▋    | 29/51 [01:17<00:54,  2.48s/it]
Number of matches 15688
Number of matches After Lowe's Ratio 3816
Number of Robust matches 1792


 59%|█████▉    | 30/51 [01:20<00:53,  2.56s/it]
Number of matches 17420
Number of matches After Lowe's Ratio 2733
Number of Robust matches 1213
```

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```
 63%|██████▎   | 32/51 [01:27<00:55,  2.95s/it]
Number of matches 17141
Number of matches After Lowe's Ratio 2902
Number of Robust matches 1074


 65%|██████▍   | 33/51 [01:30<00:53,  2.96s/it]
Number of matches 16532
Number of matches After Lowe's Ratio 3727
Number of Robust matches 1687


 67%|██████▋   | 34/51 [01:33<00:50,  2.95s/it]
Number of matches 16131
Number of matches After Lowe's Ratio 3747
Number of Robust matches 2086


 69%|██████▊   | 35/51 [01:35<00:45,  2.84s/it]
Number of matches 16216
```

```
Number of matches 16216
Number of matches After Lowe's Ratio 4108
Number of Robust matches 2455


 71%|███████   | 36/51 [01:38<00:42,  2.81s/it]
Number of matches 16510
Number of matches After Lowe's Ratio 4945
Number of Robust matches 2973


 73%|███████▎  | 37/51 [01:41<00:40,  2.87s/it]
Number of matches 17140
Number of matches After Lowe's Ratio 4422
Number of Robust matches 2679
```

```
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)):
                                                        pe(-1, 1, 2)


                                                        pe(-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]
```

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View runtime logs

```
      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),axi

    [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


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []
```

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View runtime logs

```
      result = cv2.warpPerspective(images_left[j+1], H_trans, (xmax-xmin, ymax-ymin))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)

    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    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_imgs_right.append(result)

  print('Step32:Done')

  return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
  #Union

  warp_images_all = warp_imgs_left + warp_imgs_right

  warp_img_init = warp_images_all[0]



  #warp_final_all=[]

  for j,warp_img in enumerate(warp_images_all):
    if j==len(warp_images_all)-1:
      break
    black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

    warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

    #warp_final_all.append(warp_img_init[j+1])
```



```
  return warp_img_init


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
    input_img = images_left[j+1]
    result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

    cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
    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[:, :,

        warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

      print('Step31:Done')

      return warp_img_init_prev

  def final_steps_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
        input_img = images_right[j+1]
        result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

        cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
        warp_img_init_curr = result

        black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &
```

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View runtime logs

```
      return warp_img_prev

  xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en


       Step1:Done
       Step2:Done


  warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_surfsift,xmax,xmin,



  warp_imgs_all_surfsift = final_steps_right_union(warp_imgs_left,images_right_bgr_no_enhance,H


  fig,ax =plt.subplots()
  fig.set_size_inches(20,20)
  ax.imshow(cv2.cvtColor(warp_imgs_all_surfsift , cv2.COLOR_BGR2RGB))
```

```
ax.set_title('120-Images Mosaic-SURFSIFT')
```

```
nOctaves = 6;
nOctaveLayers = 4;
kaze = cv2.KAZE_create(nOctaves, nOctaveLayers )


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]))
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
  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%|██████████| 51/51 [02:20<00:00,  2.75s/it]
    100%|██████████| 50/50 [02:16<00:00,  2.72s/it]
```

```
#num_kps_sift = []
#num_kps_brisk = []
#num_kps_agast = []
num_kps_kaze = []
#num_kps_akaze = []
#num_kps_orb = []
#num_kps_mser = []
#num_kps_daisy = []
#num_kps_surfsift = []
#num_kps_fast = []
#num_kps_freak = []
#num_kps_gftt = []
```

```
#num_kps_star = []

#for j in tqdm(keypoints_all_left_sift + keypoints_all_right_sift):
#  num_kps_sift.append(len(j))

#for j in tqdm(keypoints_all_left_brisk + keypoints_all_right_brisk):
  #num_kps_brisk.append(len(j))

#for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):
  #num_kps_agast.append(len(j))

for j in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):
  num_kps_kaze.append(len(j))
  print(len(j))

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

#for j in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
  #num_kps_orb.append(len(j))

#for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
 # num_kps_mser.append(len(j))

#for j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
#  num_kps_daisy.append(len(j))

#for j in tqdm(keypoints_all_left_surfsift + keypoints_all_right_surfsift):
```

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View runtime logs

```
#for j in tqdm(keypoints_all_left_freak + keypoints_all_right_freak):
  #num_kps_freak.append(len(j))

#for j in tqdm(keypoints_all_left_gftt + keypoints_all_right_gftt):
  #num_kps_gftt.append(len(j))

#for j in tqdm(keypoints_all_left_star + keypoints_all_right_star):
  #num_kps_star.append(len(j))
```

```
100%|██████████| 101/101 [00:00<00:00, 26787.95it/s]8614
6740
8970
7429
8840
8655
9736
10090
9604
9010
8743
```

```
8859
8830
8764
9083
8687
9361
8818
9486
8412
9007
8661
9489
9365
9518
8346
7981
7381
8088
9647
10552
11111
10114
9247
8976
8460
8931
9502
9727
9570
9374
```

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View runtime logs

```
8493
8274
8036
8124
8614
7800
7351
7371
7721
8824
6727
6578
```

```
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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
    return H, inliers


def compute_homography_fast_other(matched_pts1, matched_pts2):
    #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,
                                    0)
    inliers = inliers.flatten()
    return H, inliers


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])
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
  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_1.append((m[0].trainIdx, m[0].queryIdx))
        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])
  matches_idx = np.array([m.trainIdx for m in matches_4])
  imm2_pts = np.array([keypts[1][idx].pt for idx in matches_idx])
  '''
  # Estimate homography 1
  #Compute H1
  # Estimate homography 1
  #Compute H1
```

```
#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, RANSACthresh=6)
'''



Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
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:
```

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View runtime logs

```
es_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,fl
  displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)
```

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


print(left_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
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
```

:-1],keypoints_all_left_kaze[j

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View runtime logs

```
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_right_kaze
  H_right_kaze.append(H_a)
  num_matches_kaze.append(matches)
  num_good_matches_kaze.append(gd_matches)
```

```
  2%|▌          | 1/51 [00:01<00:55,  1.11s/it]
Number of matches 6740
Number of matches After Lowe's Ratio 1310
Number of Robust matches 938


  4%|▉          | 2/51 [00:02<00:52,  1.06s/it]
Number of matches 8970
Number of matches After Lowe's Ratio 1635
Number of Robust matches 1041
```

```
  6%|▌         | 3/51 [00:03<00:52,  1.10s/it]
Number of matches 7429
Number of matches After Lowe's Ratio 1326
Number of Robust matches 876


  8%|▊         | 4/51 [00:04<00:50,  1.06s/it]
Number of matches 8840
Number of matches After Lowe's Ratio 2857
Number of Robust matches 2489


 10%|▉         | 5/51 [00:05<00:50,  1.10s/it]
Number of matches 8655
Number of matches After Lowe's Ratio 682
Number of Robust matches 511


 12%|█▏        | 6/51 [00:06<00:50,  1.13s/it]
Number of matches 9736
Number of matches After Lowe's Ratio 2250
Number of Robust matches 2004


 14%|█▎        | 7/51 [00:08<00:55,  1.26s/it]
Number of matches 10090
Number of matches After Lowe's Ratio 3601
Number of Robust matches 2859
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
 18%|█▋        | 9/51 [00:10<00:54,  1.30s/it]
Number of matches 9010
Number of matches After Lowe's Ratio 3181
Number of Robust matches 2387


 20%|█▉        | 10/51 [00:12<00:52,  1.28s/it]
Number of matches 8743
Number of matches After Lowe's Ratio 3261
Number of Robust matches 2385
```

```
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:
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
    print('Step1:Done')


    #pts = np.concatenate((pts1, pts2_), axis=0)

    pts_concat = np.concatenate((pts_centre,np.concatenate(np.array(pts_left_transformed),axi

    [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


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):
```

```
    warp_imgs_left = []


    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))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)

    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    for j,H in enumerate(H_right):
      if j==0:
        H_trans = Ht@H
      else:
```



```
(xmax-xmin, ymax-ymin))

    print('Step32:Done')

    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
    #Union

    warp_images_all = warp_imgs_left + warp_imgs_right

    warp_img_init = warp_images_all[0]



    #warp_final_all=[]

    for j,warp_img in enumerate(warp_images_all):
      if j==len(warp_images_all)-1:
        break
      black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &
```

```
        warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

        #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
        #warp_img_init = warp_final
        #warp_final_all.append(warp_final)

      print('Step4:Done')


      return warp_img_init


  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
        input_img = images_left[j+1]
        result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

        cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
        warp_img_init_curr = result
```



```
        black_pixels = np.where((warp_img_init_prev[:, :, 0] == 0) & (warp_img_init_prev[:, :,

        warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

      print('Step31:Done')

      return warp_img_init_prev

  def final_steps_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
        input_img = images_right[j+1]
        result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

        cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
```

```
        warp_img_init_curr = result

        black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

        warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step32:Done')

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en


     Step1:Done
     Step2:Done


warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_kaze,xmax,xmin,ymax



warp_imgs_all_kaze = final_steps_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_rig



fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_kaze , cv2.COLOR_BGR2RGB))
```

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View runtime logs

```
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%|██████████| 51/51 [00:42<00:00,  1.19it/s]
   100%|██████████| 50/50 [00:41<00:00,  1.20it/s]
```

```
#num_kps_sift = []
#num_kps_brisk = []
#num_kps_agast = []
#num_kps_kaze = []
#num_kps_akaze = []
#num_kps_orb = []
#num_kps_mser = []
num_kps_daisy = []
#num_kps_surfsift = []
#num_kps_fast = []
#num_kps_freak = []
#num_kps_gftt = []
#num_kps_star = []

#for j in tqdm(keypoints_all_left_sift + keypoints_all_right_sift):
#  num_kps_sift.append(len(j))

#for j in tqdm(keypoints_all_left_brisk + keypoints_all_right_brisk):

#for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):

#for j in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):
#  num_kps_kaze.append(len(j))

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

#for j in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
  #num_kps_orb.append(len(j))

#for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
 # num_kps_mser.append(len(j))

for j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
  num_kps_daisy.append(len(j))

#for j in tqdm(keypoints_all_left_surfsift + keypoints_all_right_surfsift):
#  num_kps_surfsift.append(len(j))

#for j in tqdm(keypoints_all_left_fast + keypoints_all_right_fast):
```

```
  #num_kps_fast.append(len(j))

#for j in tqdm(keypoints_all_left_freak + keypoints_all_right_freak):
  #num_kps_freak.append(len(j))

#for j in tqdm(keypoints_all_left_gftt + keypoints_all_right_gftt):
  #num_kps_gftt.append(len(j))

#for j in tqdm(keypoints_all_left_star + keypoints_all_right_star):
  #num_kps_star.append(len(j))
```

```
100%|██████████| 101/101 [00:00<00:00, 264269.93it/s]
```

```
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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
    return H, inliers


def compute_homography_fast_other(matched_pts1, matched_pts2):
    #matched_pts1 = cv2.KeyPoint_convert(matched_kp1)
```



```
                                    0)
    inliers = inliers.flatten()
    return H, inliers


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_1.append((m[0].trainIdx, m[0].queryIdx))
      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])
matches_idx = np.array([m.trainIdx for m in matches_4])
imm2_pts = np.array([keypts[1][idx].pt for idx in matches_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
```

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```
nRANSAC=1000, RANSACthresh=6)
'''


Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
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,fl
    displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

  return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


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

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```
4.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
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[
  H_left_daisy.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_right_dais
  H_right_daisy.append(H_a)
  #num_matches.append(matches)
  #num_good_matches.append(gd_matches)
```

```
Number of matches 10755
Number of matches After Lowe's Ratio 2625
Number of Robust matches 1287


 80%|████████  | 40/50 [01:27<00:23,  2.36s/it]
Number of matches 11708
Number of matches After Lowe's Ratio 1375
Number of Robust matches 557


 82%|████████▏  | 41/50 [01:30<00:21,  2.40s/it]
Number of matches 11333
Number of matches After Lowe's Ratio 1230
Number of Robust matches 684


 84%|████████▍  | 42/50 [01:32<00:19,  2.43s/it]
Number of matches 10893
Number of matches After Lowe's Ratio 1954
```

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```
Number of matches After Lowe's Ratio 1516
Number of Robust matches 823


 88%|████████▊  | 44/50 [01:37<00:13,  2.32s/it]
Number of matches 9619
Number of matches After Lowe's Ratio 1147
Number of Robust matches 930


 90%|█████████ | 45/50 [01:39<00:11,  2.25s/it]
Number of matches 9828
Number of matches After Lowe's Ratio 1602
Number of Robust matches 1086


 92%|█████████▏| 46/50 [01:41<00:08,  2.20s/it]
Number of matches 9149
Number of matches After Lowe's Ratio 1474
Number of Robust matches 1001
```

```
 94%|█████████▍ | 47/50 [01:43<00:06,  2.13s/it]
Number of matches 8680
Number of matches After Lowe's Ratio 2711
Number of Robust matches 1980


 96%|█████████▌ | 48/50 [01:45<00:04,  2.04s/it]
Number of matches 9125
Number of matches After Lowe's Ratio 1300
Number of Robust matches 784


 98%|█████████▊ | 49/50 [01:47<00:02,  2.25s/it]
```

```
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)
```

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```
pe(-1, 1, 2)

    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),axi

    [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


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []


    for j,H in enumerate(H_left):
      if j==0:
        H_trans = Ht@H
```



```
(xmax-xmin, ymax-ymin))
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)

    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    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_imgs_right.append(result)
```

```
        warp_imgs_right.append(result)

    print('Step32:Done')

    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
    #Union

    warp_images_all = warp_imgs_left + warp_imgs_right

    warp_img_init = warp_images_all[0]



    #warp_final_all=[]

    for j,warp_img in enumerate(warp_images_all):
      if j==len(warp_images_all)-1:
        break
      black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

      warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

      #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
      #warp_img_init = warp_final
      #warp_final_all.append(warp_final)
```

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```
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
      input_img = images_left[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      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[:, :,

          warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

        print('Step31:Done')

        return warp_img_init_prev

    def final_steps_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
          input_img = images_right[j+1]
          result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

          cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
          warp_img_init_curr = result

          black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

          warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

        print('Step32:Done')
```

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```
    enhance, images_right_bgr_no_en

    Step1:Done
    Step2:Done


warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_daisy,xmax,xmin,yma


warp_imgs_all_daisy = final_steps_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_ri


fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_daisy , cv2.COLOR_BGR2RGB))
ax.set_title('120-Images Mosaic-DAISY')
```

```
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]))

    100%|██████████| 51/51 [00:08<00:00,  6.21it/s]
```

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```
#num_kps_kaze = []
#num_kps_akaze = []
#num_kps_orb = []
#num_kps_mser = []
#num_kps_daisy = []
#num_kps_surfsift = []
#num_kps_fast = []
#num_kps_freak = []
#num_kps_gftt = []
num_kps_star = []

#for j in tqdm(keypoints_all_left_sift + keypoints_all_right_sift):
#  num_kps_sift.append(len(j))

#for j in tqdm(keypoints_all_left_brisk + keypoints_all_right_brisk):
  #num_kps_brisk.append(len(j))

#for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):
  #num_kps_agast.append(len(j))
```

```
#for j in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):
#  num_kps_kaze.append(len(j))

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

#for j in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
  #num_kps_orb.append(len(j))

#for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
 # num_kps_mser.append(len(j))

#for j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
#  num_kps_daisy.append(len(j))

#for j in tqdm(keypoints_all_left_surfsift + keypoints_all_right_surfsift):
#  num_kps_surfsift.append(len(j))

#for j in tqdm(keypoints_all_left_fast + keypoints_all_right_fast):
  #num_kps_fast.append(len(j))

#for j in tqdm(keypoints_all_left_freak + keypoints_all_right_freak):
  #num_kps_freak.append(len(j))

#for j in tqdm(keypoints_all_left_gftt + keypoints_all_right_gftt):
  #num_kps_gftt.append(len(j))
```

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View runtime logs

```
ar):


1):
    #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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
    return H, inliers


def compute_homography_fast_other(matched_pts1, matched_pts2):
    #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,
                                    0)
    inliers = inliers.flatten()
```

```
    inliers = inliers.flatten()
    return H, inliers


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_1.append((m[0].trainIdx, m[0].queryIdx))
        matches_4.append(m[0])
```

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```
  matches_idx = np.array([m.trainIdx for m in matches_4])
  imm2_pts = np.array([keypts[1][idx].pt for idx in matches_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, RANSACthresh=6)
  '''
```

```
  Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
  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")
    '''
```

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```
, RANSACthresh=6)
```

```
  if disp==True:
    dispimg1=cv2.drawMatches(imgs[0], keypts[0], imgs[1], keypts[1], inlier_matchset, None,fl
    displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

  return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


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


print(left_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
H_left_brief = []
H_right_brief = []

num_matches_brief = []
num_good_matches_brief = []

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
  H_left_brief.append(H_a)
  num_matches_brief.append(matches)
  num_good_matches_brief.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_right_star
  H_right_brief.append(H_a)
  num_matches_brief.append(matches)
  num_good_matches_brief.append(gd_matches)
```

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```
    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),axi

    [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]
                                                                    translate
```



```
    return xmax,xmin,ymax,ymin,t,h,w,Ht


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []


    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))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)
```

```
    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    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_imgs_right.append(result)

    print('Step32:Done')

    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
    #Union

    warp_images_all = warp_imgs_left + warp_imgs_right

    warp_img_init = warp_images_all[0]
```



```
    for j,warp_img in enumerate(warp_images_all):
      if j==len(warp_images_all)-1:
        break
      black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

      warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

      #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
      #warp_img_init = warp_final
      #warp_final_all.append(warp_final)

    print('Step4:Done')


    return warp_img_init


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
      input_img = images_left[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      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[:, :,

      warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step31:Done')

    return warp_img_init_prev

def final_steps_right_union(warp_img_prev,images_right,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):
```



```
      input_img = images_right[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      warp_img_init_curr = result

      black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

      warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step32:Done')

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en


     Step1:Done
```

```
Step2:Done
```

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_brief,xmax,xmin,yma
```

```
Step31:Done
```

```
warp_imgs_all_brief = final_steps_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_ri
```

```
Step32:Done
```

```
fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_brief , cv2.COLOR_BGR2RGB))
ax.set_title('100-Images Mosaic-BRIEF')
```

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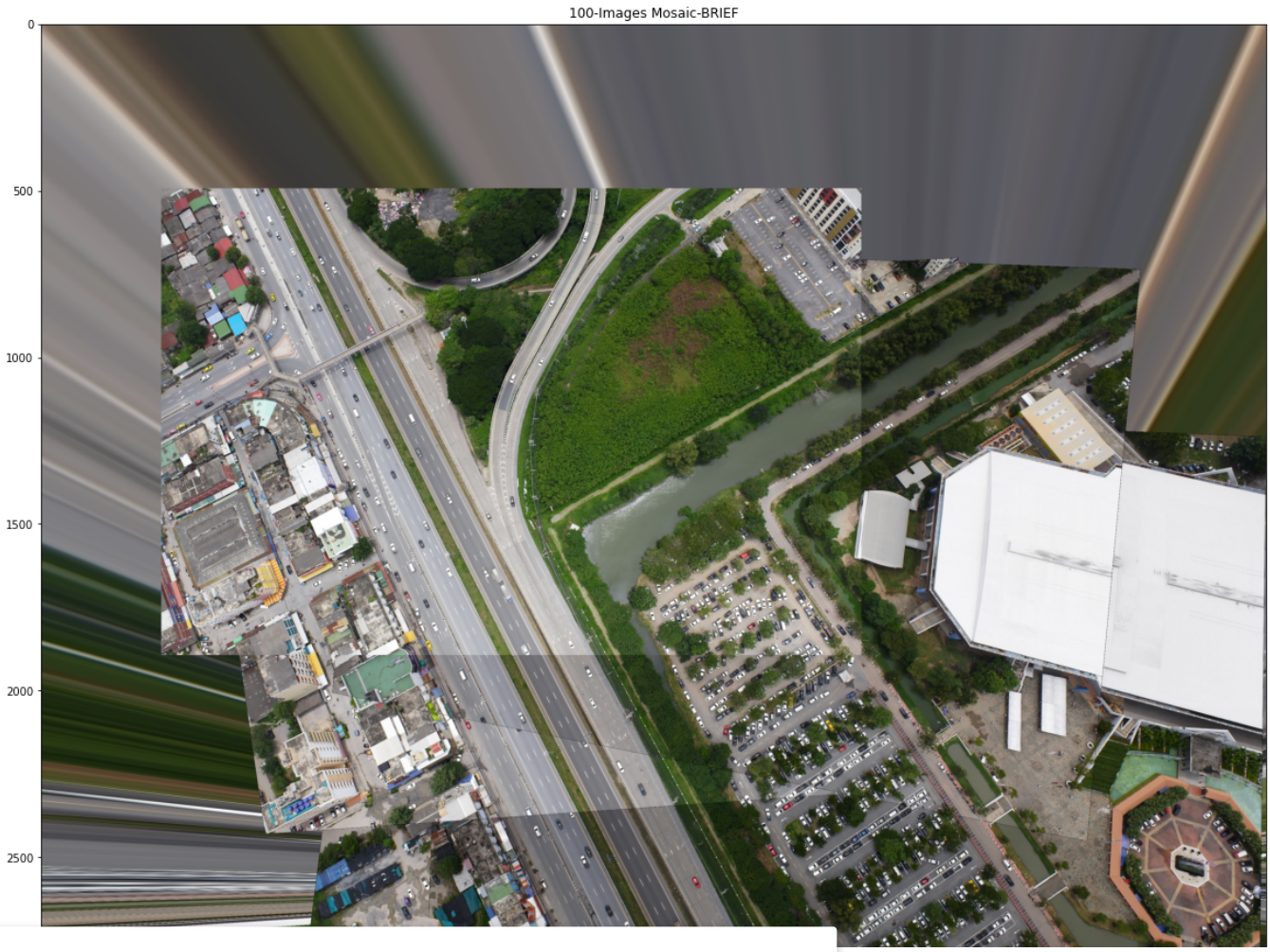
```
Text(0.5, 1.0, '100-Images Mosaic-BRIEF')
```




```
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)


    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)
```

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

```
    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):
      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):
    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 [03:22<00:00,  3.32s/it]
      100%|██████████| 61/61 [03:09<00:00,  3.11s/it]


  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, ransacReprojThreshold =thresh)
      inliers = inliers.flatten()
      return H, inliers


  def compute_homography_fast_other(matched_pts1, matched_pts2):
      #matched_pts1 = cv2.KeyPoint_convert(matched_kp1)
```

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```
                                      0)
      inliers = inliers.flatten()
      return H, inliers


  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_1.append((m[0].trainIdx, m[0].queryIdx))
      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])
matches_idx = np.array([m.trainIdx for m in matches_4])
imm2_pts = np.array([keypts[1][idx].pt for idx in matches_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
```

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```
nRANSAC=1000, RANSACthresh=6)
'''


Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
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,fl
    displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

  return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


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

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```
L.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0060.JPG', '/content/drive/MyDrive
```

```
H_left_rootsift = []
H_right_rootsift = []

num_matches_rootsift = []
num_good_matches_rootsift = []

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_rootsi
  H_left_rootsift.append(H_a)
  num_matches_rootsift.append(matches)
  num_good_matches_rootsift.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_right_root
  H_right_rootsift.append(H_a)
  #num_matches.append(matches)
  #num_good_matches.append(gd_matches)
```

```
  2%|▏          | 1/61 [00:06<06:35,  6.59s/it]
Number of matches 28871
Number of matches After Lowe's Ratio 2381
Number of Robust matches 1347


  3%|▎          | 2/61 [00:13<06:28,  6.59s/it]
Number of matches 35330
Number of matches After Lowe's Ratio 1675
Number of Robust matches 879


  5%|▍          | 3/61 [00:20<06:43,  6.96s/it]
Number of matches 32332
Number of matches After Lowe's Ratio 626
Number of Robust matches 245


  7%|▋          | 4/61 [00:28<06:39,  7.01s/it]
```

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```
  8%|▊          | 5/61 [00:35<06:36,  7.08s/it]
Number of matches 32463
Number of matches After Lowe's Ratio 5257
Number of Robust matches 3471


 10%|▉          | 6/61 [00:44<07:06,  7.76s/it]
Number of matches 32266
Number of matches After Lowe's Ratio 4943
Number of Robust matches 2575


 11%|█          | 7/61 [00:54<07:33,  8.40s/it]
Number of matches 32877
Number of matches After Lowe's Ratio 5372
Number of Robust matches 3219


 13%|█▏         | 8/61 [01:02<07:10,  8.12s/it]
Number of matches 27613
Number of matches After Lowe's Ratio 3080
Number of Robust matches 2047
```

```
 15%|█▌        | 9/61 [01:07<06:27,  7.45s/it]
Number of matches 31966
Number of matches After Lowe's Ratio 4270
Number of Robust matches 2660


 16%|█▋        | 10/61 [01:14<06:05,  7.17s/it]
Number of matches 23666
Number of matches After Lowe's Ratio 1857
Number of Robust matches 1229
```

```
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:
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
:-1],keypoints_all_left_sift[j
  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_right_sift
  H_right_sift.append(H_a)
  #num_matches.append(matches)
  #num_good_matches.append(gd_matches)


  2%|▏         | 1/61 [00:06<06:32,  6.55s/it]
Number of matches 28871
Number of matches After Lowe's Ratio 571
Number of Robust matches 480


  3%|▎         | 2/61 [00:13<06:26,  6.55s/it]
Number of matches 35330
```

```
Number of matches After Lowe's Ratio 352
Number of Robust matches 281


  5%|▌          | 3/61 [00:20<06:39,  6.88s/it]
Number of matches 32332
Number of matches After Lowe's Ratio 74
Number of Robust matches 54


  7%|▋          | 4/61 [00:27<06:33,  6.91s/it]
Number of matches 32125
Number of matches After Lowe's Ratio 1498
Number of Robust matches 975


  8%|▊          | 5/61 [00:34<06:32,  7.01s/it]
Number of matches 32463
Number of matches After Lowe's Ratio 1694
Number of Robust matches 898


 10%|▉          | 6/61 [00:41<06:25,  7.00s/it]
Number of matches 32266
Number of matches After Lowe's Ratio 1656
Number of Robust matches 1037


 11%|█          | 7/61 [00:49<06:19,  7.04s/it]
Number of matches 32877
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
Number of matches After Lowe's Ratio 759
Number of Robust matches 517


 15%|█▍         | 9/61 [01:01<05:39,  6.53s/it]
Number of matches 31966
Number of matches After Lowe's Ratio 1288
Number of Robust matches 820


 16%|█▌         | 10/61 [01:08<05:37,  6.62s/it]
Number of matches 23666
Number of matches After Lowe's Ratio 502
Number of Robust matches 428
```

```
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):
```

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View runtime logs

```
  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),axi

[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
```

```
def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []


    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))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)

    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    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_imgs_right.append(result)

    print('Step32:Done')

    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
    #Union

    warp_images_all = warp_imgs_left + warp_imgs_right

    warp_img_init = warp_images_all[0]



    #warp_final_all=[]

    for j,warp_img in enumerate(warp_images_all):
```

```
        if j==len(warp_images_all)-1:
          break
        black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

        warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

        #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
        #warp_img_init = warp_final
        #warp_final_all.append(warp_final)

      print('Step4:Done')


      return warp_img_init


  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
        input_img = images_left[j+1]
        result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')
```



```
ns, dsize = (xmax-xmin, ymax-ym

        warp_img_init_prev = result
        continue

        black_pixels = np.where((warp_img_init_prev[:, :, 0] == 0) & (warp_img_init_prev[:, :,

        warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

      print('Step31:Done')

      return warp_img_init_prev

  def final_steps_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
        input_img = images_right[j+1]
```

```
        result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

        cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
        warp_img_init_curr = result

        black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

        warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step32:Done')

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en
```

```
Step1:Done
Step2:Done
```

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_rootsift,xmax,xmin,


warp_imgs_all_rootsift = final_steps_right_union(warp_imgs_left,images_right_bgr_no_enhance,H
```

```
Step32:Done
```

```
fig,ax =plt.subplots()
```

```
RGB))
```

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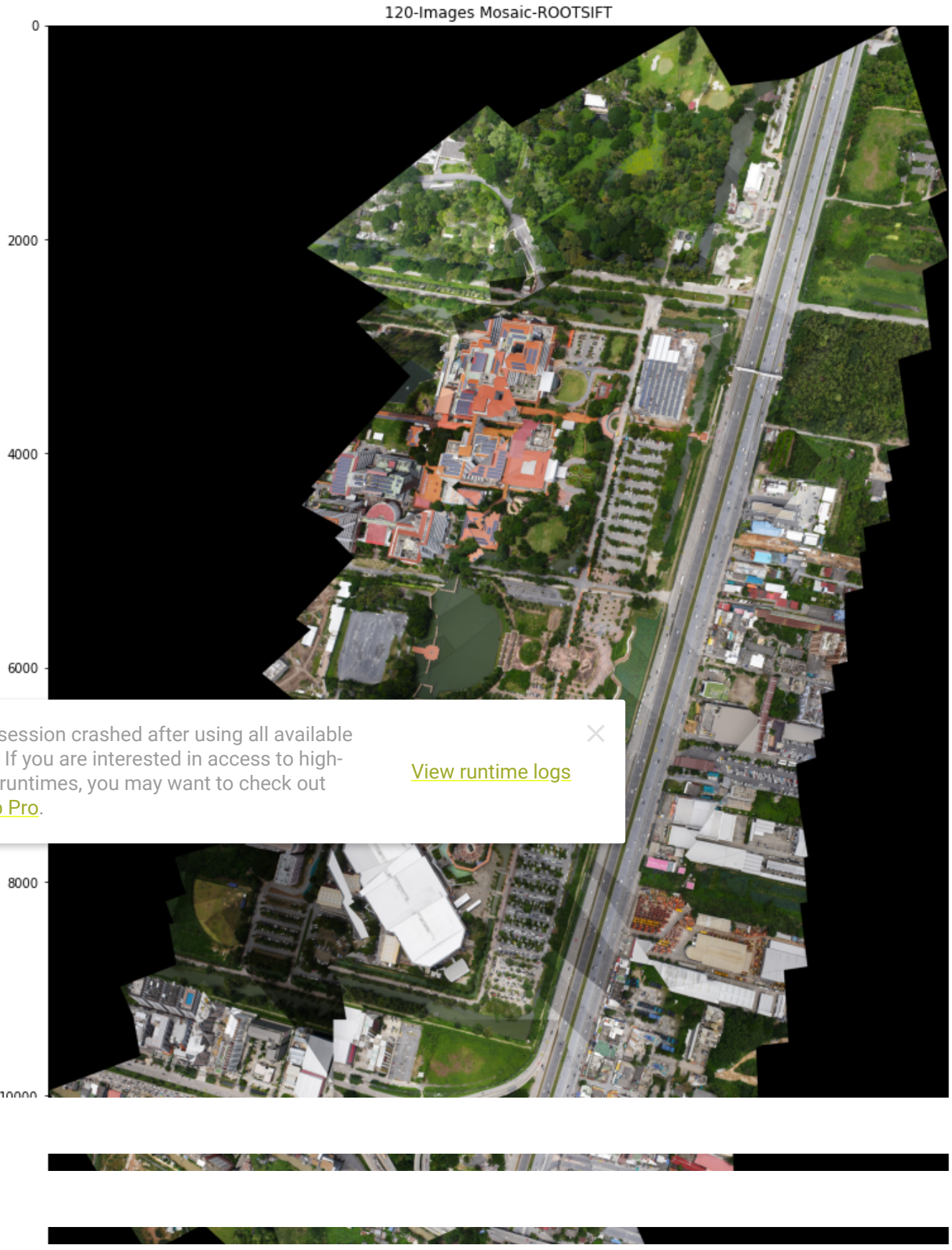
```
Text(0.5, 1.0, '120-Images Mosaic-ROOTSIFT')
```




```
xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en
```

```
Step1:Done
Step2:Done
```

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_sift,xmax,xmin,ymax
```

```
    Step31:Done
```

```
warp_imgs_all_sift = final_steps_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_rig
```

```
    Step32:Done
```

```
fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_sift , cv2.COLOR_BGR2RGB))
ax.set_title('120-Images Mosaic-SIFT')
```

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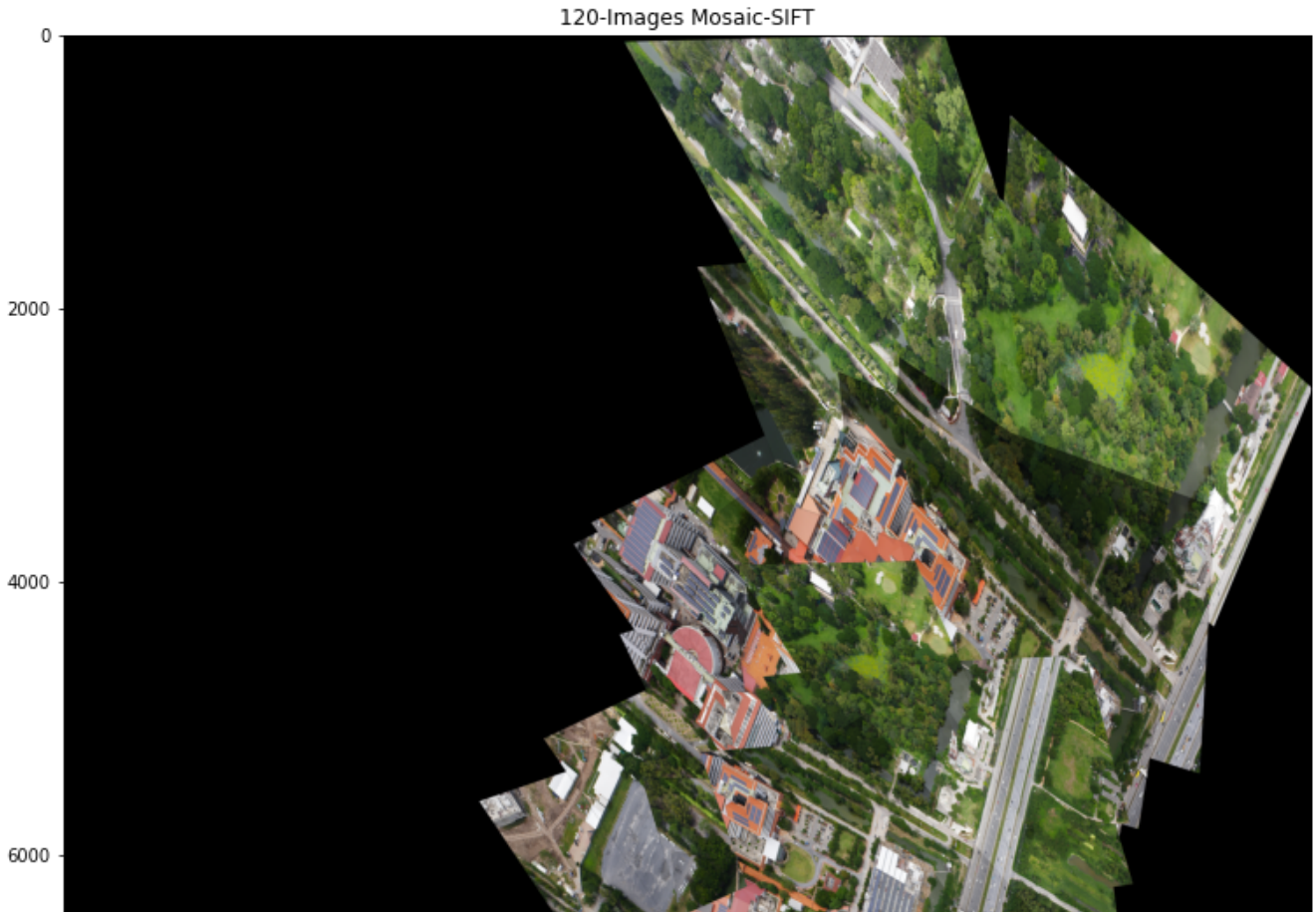
View runtime logs

```
Text(0.5, 1.0, '120-Images Mosaic-SIFT')
```




```
akaze = cv2.AKAZE_create()
```

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```
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 [01:29<00:00,  1.47s/it]
100%|██████████| 61/61 [01:28<00:00,  1.45s/it]
```

```
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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
    return H, inliers


def compute_homography_fast_other(matched_pts1, matched_pts2):
    #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,
                                    0)
    inliers = inliers.flatten()
    return H, inliers


def get_Hmatrix(imgs,keypts,pts,descripts,ratio=0.8,thresh=4,disp=False):
```

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```
  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_1.append((m[0].trainIdx, m[0].queryIdx))
        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])
matches_idx = np.array([m.trainIdx for m in matches_4])
imm2_pts = np.array([keypts[1][idx].pt for idx in matches_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, RANSACthresh=6)
'''



Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
inlier_matchset = np.array(matches_4)[inliers.astype(bool)].tolist()
```

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```
  # 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,fl
    displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

  return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


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


print(left_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0064.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0063.JPG', '/content/drive/MyDrive
```

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```
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[
  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_right_akaz
  H_right_akaze.append(H_a)
  #num_matches.append(matches)
  #num_good_matches.append(gd_matches)
```

```
  2%|▏          | 1/61 [00:01<01:37,  1.63s/it]
Number of matches 20771
Number of matches After Lowe's Ratio 2771
Number of Robust matches 2138


  3%|▏          | 2/61 [00:03<01:38,  1.67s/it]
Number of matches 18233
Number of matches After Lowe's Ratio 2533
Number of Robust matches 1689


  5%|▍          | 3/61 [00:04<01:32,  1.60s/it]
Number of matches 16819
Number of matches After Lowe's Ratio 1416
Number of Robust matches 834


  7%|▋          | 4/61 [00:06<01:27,  1.53s/it]
Number of matches 16167
Number of matches After Lowe's Ratio 992
Number of Robust matches 437


  8%|▊          | 5/61 [00:07<01:23,  1.49s/it]
Number of matches 21720
Number of matches After Lowe's Ratio 912
Number of Robust matches 264
```

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View runtime logs

```
 11%|█          | 7/61 [00:10<01:24,  1.57s/it]
Number of matches 18110
Number of matches After Lowe's Ratio 2194
Number of Robust matches 1278


 13%|█▏         | 8/61 [00:12<01:22,  1.55s/it]
Number of matches 18754
Number of matches After Lowe's Ratio 2316
Number of Robust matches 1354


 15%|█▍         | 9/61 [00:14<01:20,  1.56s/it]
Number of matches 19049
Number of matches After Lowe's Ratio 2346
Number of Robust matches 1152


 16%|█▋         | 10/61 [00:15<01:22,  1.62s/it]
Number of matches 20428
```

```
 Number of matches After Lowe's Ratio 2484
 Number of Robust matches 1632
```

```
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):
```

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```
      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),axi

    [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


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []


    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))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)

    print('Step31:Done')
```

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View runtime logs

```
xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    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_imgs_right.append(result)

    print('Step32:Done')

    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
    #Union

    warp_images_all = warp_imgs_left + warp_imgs_right
```

```
    warp_img_init = warp_images_all[0]



    #warp_final_all=[]

    for j,warp_img in enumerate(warp_images_all):
      if j==len(warp_images_all)-1:
        break
      black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

      warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

      #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
      #warp_img_init = warp_final
      #warp_final_all.append(warp_final)

    print('Step4:Done')


    return warp_img_init


def final_steps_left_union(images_left,H_left,xmax,xmin,ymax,ymin,t,h,w,Ht):
```



```
      input_img = images_left[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      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[:, :,

      warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step31:Done')

    return warp_img_init_prev
```

```
def final_steps_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
      input_img = images_right[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      warp_img_init_curr = result

      black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

      warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step32:Done')

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en
```

```
 Step1:Done
 Step2:Done
```

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View runtime logs

```
ance,H_left_akaze,xmax,xmin,yma

mages_right_bgr_no_enhance,H_ri
```

```
fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_akaze , cv2.COLOR_BGR2RGB))
ax.set_title('101-Images Mosaic-AKAZE')
```

```
Text(0.5, 1.0, '101-Images Mosaic-AKAZE')
```


```
Threshl=40;
Octaves=3;
```

```
    #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]))

        100%|██████████| 51/51 [00:46<00:00,  1.10it/s]
```

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View runtime logs

```
    ):
        #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, ransacReprojThreshold =thresh)
        inliers = inliers.flatten()
        return H, inliers


    def compute_homography_fast_other(matched_pts1, matched_pts2):
        #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,
                                        0)
        inliers = inliers.flatten()
        return H, inliers
```

```
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_1.append((m[0].trainIdx, m[0].queryIdx))
        matches_4.append(m[0])

  print("Number of matches After Lowe's Ratio",len(matches_4))
```

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View runtime logs

```
  '''
  # 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, RANSACthresh=6)
  '''
```

```
    Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
    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)
```

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View runtime logs

```
, RANSACthresh=6)

    if disp==True:
      dispimg1=cv2.drawMatches(imgs[0], keypts[0], imgs[1], keypts[1], inlier_matchset, None,fl
      displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

    return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


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


print(left_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
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[
  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_right_bris
  H_right_brisk.append(H_a)
  #num_matches.append(matches)
  #num_good_matches.append(gd_matches)
```

```
    Number of matches After Lowe's Ratio 5717
```

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View runtime logs

```
    Number of Robust matches 2293


     33%|███▎      | 17/51 [00:50<01:47,  3.17s/it]
    Number of matches 29418
    Number of matches After Lowe's Ratio 5722
    Number of Robust matches 1796


     35%|███▍      | 18/51 [00:53<01:49,  3.33s/it]
    Number of matches 34254
    Number of matches After Lowe's Ratio 6400
    Number of Robust matches 1530


     37%|███▋      | 19/51 [00:57<01:53,  3.56s/it]
    Number of matches 30446
    Number of matches After Lowe's Ratio 5753
    Number of Robust matches 1327


     39%|███▉      | 20/51 [01:01<01:49,  3.52s/it]
```

```
 39%|████      | 20/51 [01:01<01:49,  3.52s/it]
Number of matches 28308
Number of matches After Lowe's Ratio 5269
Number of Robust matches 1339


 41%|████      | 21/51 [01:04<01:44,  3.48s/it]
Number of matches 27232
Number of matches After Lowe's Ratio 5048
Number of Robust matches 1142


 43%|████▏     | 22/51 [01:07<01:38,  3.40s/it]
Number of matches 30938
Number of matches After Lowe's Ratio 4771
Number of Robust matches 577


 45%|████▌     | 23/51 [01:11<01:38,  3.53s/it]
Number of matches 32332
Number of matches After Lowe's Ratio 5638
Number of Robust matches 1299


 47%|████▋     | 24/51 [01:15<01:37,  3.61s/it]
Number of matches 30965
Number of matches After Lowe's Ratio 4336

Number of Robust matches 260
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
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),axi

    [xmin, ymin] = np.int32(pts_concat.min(axis=0).ravel() - 0.5)
    [xmax, ymax] = np.int32(pts_concat.max(axis=0).ravel() + 0.5)
```

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View runtime logs

```
translate


    return xmax,xmin,ymax,ymin,t,h,w,Ht


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []


    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))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)
```

```
    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    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_imgs_right.append(result)

    print('Step32:Done')

    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
    #Union

    warp_images_all = warp_imgs_left + warp_imgs_right
```

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View runtime logs

```
    for j,warp_img in enumerate(warp_images_all):
      if j==len(warp_images_all)-1:
        break
      black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

      warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

      #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
      #warp_img_init = warp_final
      #warp_final_all.append(warp_final)

    print('Step4:Done')


    return warp_img_init


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
      input_img = images_left[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      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[:, :,

      warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step31:Done')

    return warp_img_init_prev

def final_steps_right_union(warp_img_prev,images_right,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):
```



```
        H_trans = H_trans@H
      input_img = images_right[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      warp_img_init_curr = result

      black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

      warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step32:Done')

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en


 Step1:Done
```

```
      Step2:Done
```

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_brisk,xmax,xmin,yma
```

```
warp_imgs_all_brisk = final_steps_right_union(warp_imgs_left, images_right_bgr_no_enhance,H_r
```

```
      Step32:Done
```

```
fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_brisk , cv2.COLOR_BGR2RGB))
ax.set_title('61-Images Mosaic-BRISK')
```

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View runtime logs

```
Text(0.5, 1.0, '61-Images Mosaic-BRISK')
```


```
mser = cv2.MSER_create()
```

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View runtime logs

```
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]))
```

```
100%|██████████| 61/61 [05:42<00:00,  5.62s/it]
100%|██████████| 61/61 [06:09<00:00,  6.05s/it]


#num_kps_sift = []
#num_kps_brisk = []
#num_kps_agast = []
#num_kps_kaze = []
#num_kps_akaze = []
#num_kps_orb = []
num_kps_mser = []
#num_kps_daisy = []
#num_kps_surfsift = []
#num_kps_fast = []
#num_kps_freak = []
#num_kps_gftt = []
#num_kps_star = []

#for j in tqdm(keypoints_all_left_sift + keypoints_all_right_sift):
#  num_kps_sift.append(len(j))

#for j in tqdm(keypoints_all_left_brisk + keypoints_all_right_brisk):
  #num_kps_brisk.append(len(j))

#for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):
  #num_kps_agast.append(len(j))

#for j in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):

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akaze):

#for j in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
  #num_kps_orb.append(len(j))

for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
  num_kps_mser.append(len(j))

#for j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
#  num_kps_daisy.append(len(j))

#for j in tqdm(keypoints_all_left_surfsift + keypoints_all_right_surfsift):
#  num_kps_surfsift.append(len(j))

#for j in tqdm(keypoints_all_left_fast + keypoints_all_right_fast):
  #num_kps_fast.append(len(j))

#for j in tqdm(keypoints_all_left_freak + keypoints_all_right_freak):
  #num_kps_freak.append(len(j))

#for j in tqdm(keypoints_all_left_gftt + keypoints_all_right_gftt):
```

```
  #num_kps_gftt.append(len(j))

#for j in tqdm(keypoints_all_left_star + keypoints_all_right_star):
  #num_kps_star.append(len(j))
```

```
100%|██████████| 122/122 [00:00<00:00, 176267.68it/s]
```

```
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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
    return H, inliers


def compute_homography_fast_other(matched_pts1, matched_pts2):
    #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,
                                    0)
```

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View runtime logs

```
isp=False):
  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_1.append((m[0].trainIdx, m[0].queryIdx))
      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])
matches_idx = np.array([m.trainIdx for m in matches_4])
imm2_pts = np.array([keypts[1][idx].pt for idx in matches_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, RANSACthresh=6)
'''
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
n)
tolist()
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,fl
      displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

    return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


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


print(left_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0064.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

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View runtime logs

```
.JPG', '/content/drive/MyDrive
```

```
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
  H_left_mser.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_right_mser
```

```
H_right_mser.append(H_a)
#num_matches.append(matches)
#num_good_matches.append(gd_matches)
```

```
 49%|████▉     | 30/61 [00:09<00:09,  3.10it/s]
Number of matches 2359
Number of matches After Lowe's Ratio 809
Number of Robust matches 199


 51%|█████     | 31/61 [00:10<00:10,  2.97it/s]
Number of matches 2766
Number of matches After Lowe's Ratio 292
Number of Robust matches 50


 52%|█████▏    | 32/61 [00:10<00:10,  2.83it/s]
Number of matches 3058
Number of matches After Lowe's Ratio 270
Number of Robust matches 24


 54%|█████▍    | 33/61 [00:11<00:10,  2.62it/s]
Number of matches 3085
Number of matches After Lowe's Ratio 850
Number of Robust matches 214


 56%|█████▌    | 34/61 [00:11<00:10,  2.52it/s]
Number of matches 3255
Number of matches After Lowe's Ratio 546
```

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View runtime logs

```
Number of Robust matches 12


 59%|█████▉    | 36/61 [00:12<00:10,  2.37it/s]
Number of matches 2662
Number of matches After Lowe's Ratio 768
Number of Robust matches 182


 61%|██████    | 37/61 [00:12<00:09,  2.43it/s]
Number of matches 2577
Number of matches After Lowe's Ratio 915
Number of Robust matches 222


 62%|██████▏   | 38/61 [00:13<00:09,  2.50it/s]
Number of matches 2927
Number of matches After Lowe's Ratio 833
Number of Robust matches 205
```

```
 64%|██████    | 39/61 [00:13<00:09,  2.40it/s]
Number of matches 3331
Number of matches After Lowe's Ratio 1017
Number of Robust matches 231
```

```
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=[]
```

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View runtime logs

```
      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),axi

    [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


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []


    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))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]
```



```
    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    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_imgs_right.append(result)

    print('Step32:Done')

    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
```

```
#Union

warp_images_all = warp_imgs_left + warp_imgs_right

warp_img_init = warp_images_all[0]



#warp_final_all=[]

for j,warp_img in enumerate(warp_images_all):
  if j==len(warp_images_all)-1:
    break
  black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

  warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

  #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
  #warp_img_init = warp_final
  #warp_final_all.append(warp_final)

print('Step4:Done')


return warp_img_init
```



```
                                                                    min,t,h,w,Ht):
  if j==0:
    H_trans = Ht@H
  else:
    H_trans = H_trans@H
  input_img = images_left[j+1]
  result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

  cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
  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[:, :,

  warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

print('Step31:Done')
```

```
    return warp_img_init_prev

def final_steps_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
      input_img = images_right[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      warp_img_init_curr = result

      black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

      warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step32:Done')

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en
```

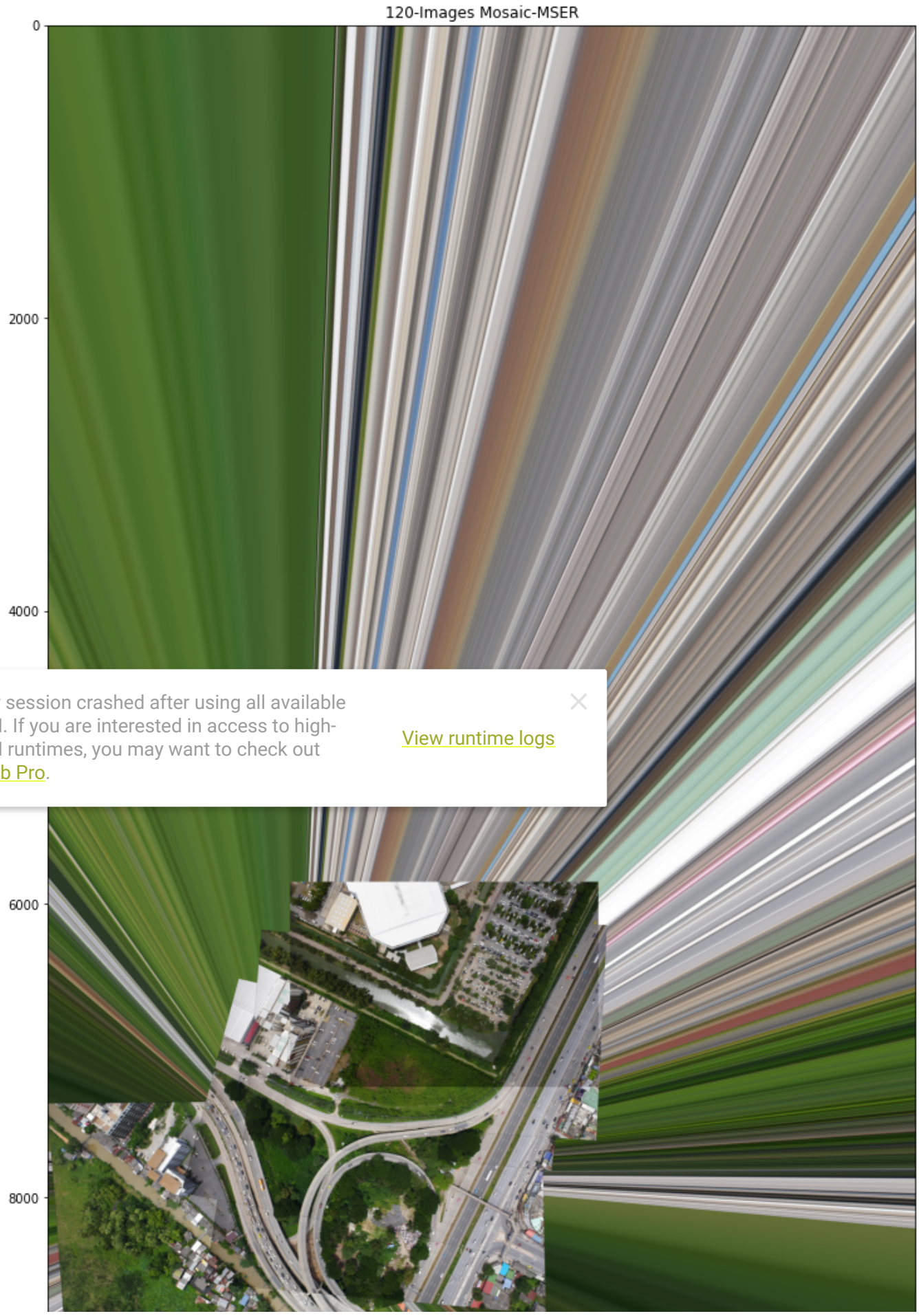


```
ance,H_left_mser,xmax,xmin,ymax
     Step31:Done

warp_imgs_all_mser = final_steps_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_rig
     Step32:Done


fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_mser , cv2.COLOR_BGR2RGB))
ax.set_title('120-Images Mosaic-MSER')
```

```
Text(0.5, 1.0, '120-Images Mosaic-MSER')
```



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View runtime logs

```
agast = cv2.AgastFeatureDetector_create(threshold = 20)
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)
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
  points_all_right_agast.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
    100%|██████████| 50/50 [02:09<00:00,  2.60s/it]

#num_kps_sift = []
#num_kps_brisk = []
num_kps_agast = []
#num_kps_kaze = []
#num_kps_akaze = []
#num_kps_orb = []
#num_kps_mser = []
#num_kps_daisy = []
#num_kps_surfsift = []
#num_kps_fast = []
#num_kps_freak = []
#num_kps_gftt = []
#num_kps_star = []

#for j in tqdm(keypoints_all_left_sift + keypoints_all_right_sift):
#  num_kps_sift.append(len(j))
```

```
#for j in tqdm(keypoints_all_left_brisk + keypoints_all_right_brisk):
  #num_kps_brisk.append(len(j))

for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):
  num_kps_agast.append(len(j))

#for j in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):
#  num_kps_kaze.append(len(j))

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

#for j in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
  #num_kps_orb.append(len(j))

#for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
#  num_kps_mser.append(len(j))

#for j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
#  num_kps_daisy.append(len(j))

#for j in tqdm(keypoints_all_left_surfsift + keypoints_all_right_surfsift):
#  num_kps_surfsift.append(len(j))

#for j in tqdm(keypoints_all_left_fast + keypoints_all_right_fast):
#  num_kps_fast.append(len(j))
```



```
freak):

ftt):

#for j in tqdm(keypoints_all_left_star + keypoints_all_right_star):
  #num_kps_star.append(len(j))
```

```
    100%|██████████| 101/101 [00:00<00:00, 35485.40it/s]
```

```
len(j)
```

```
    26155
```

```
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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
```

```
    inliers = inliers.flatten()
    return H, inliers


def compute_homography_fast_other(matched_pts1, matched_pts2):
    #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,
                                    0)
    inliers = inliers.flatten()
    return H, inliers


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)
```

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View runtime logs

```
  # 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",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])
  '''
  # 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, RANSACthresh=6)
    '''



    Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
    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))
```

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View runtime logs

```
      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,fl
      displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

    return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)
```

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


print(left_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
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[
```

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View runtime logs

```
  if j==len(images_right)-1:
    break

  H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_right_agas
  H_right_agast.append(H_a)
  #num_matches.append(matches)
  #num_good_matches.append(gd_matches)
```

```
Number of matches 29423
Number of matches After Lowe's Ratio 7517
Number of Robust matches 4580


 80%|████████  | 40/50 [04:39<01:06,  6.62s/it]
Number of matches 30953
Number of matches After Lowe's Ratio 4001
Number of Robust matches 2590


 82%|████████▏  | 41/50 [04:46<01:01,  6.79s/it]
Number of matches 31143
```

```
Number of matches After Lowe's Ratio 263
Number of Robust matches 115


 84%|████████▍  | 42/50 [04:53<00:55,  6.93s/it]
Number of matches 34202
Number of matches After Lowe's Ratio 3147
Number of Robust matches 1924


 86%|████████▌  | 43/50 [05:01<00:49,  7.10s/it]
Number of matches 28998
Number of matches After Lowe's Ratio 2319
Number of Robust matches 1429


 88%|████████▊  | 44/50 [05:08<00:41,  6.94s/it]
Number of matches 30411
Number of matches After Lowe's Ratio 1607
Number of Robust matches 1117


 90%|█████████ | 45/50 [05:14<00:34,  6.92s/it]
Number of matches 31507
Number of matches After Lowe's Ratio 2892
Number of Robust matches 2099


 92%|█████████▏| 46/50 [05:21<00:27,  6.92s/it]
Number of matches 29986
Number of matches After Lowe's Ratio 2640
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
Number of matches After Lowe's Ratio 7493
Number of Robust matches 6831


 96%|█████████▌| 48/50 [05:33<00:12,  6.42s/it]
Number of matches 26167
Number of matches After Lowe's Ratio 3642
Number of Robust matches 2923
```

```
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]
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
    #pts = np.concatenate((pts1, pts2_), axis=0)

    pts_concat = np.concatenate((pts_centre,np.concatenate(np.array(pts_left_transformed),axi

    [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


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []
```

```
    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))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)

    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    for j,H in enumerate(H_right):
      if j==0:
        H_trans = Ht@H
      else:
        H_trans = H_trans@H
```

(xmax-xmin, ymax-ymin))

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View runtime logs

```
    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
    #Union

    warp_images_all = warp_imgs_left + warp_imgs_right

    warp_img_init = warp_images_all[0]



    #warp_final_all=[]

    for j,warp_img in enumerate(warp_images_all):
      if j==len(warp_images_all)-1:
        break
      black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

      warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]
```

```
      warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

      #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
      #warp_img_init = warp_final
      #warp_final_all.append(warp_final)

    print('Step4:Done')


    return warp_img_init


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
      input_img = images_left[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      warp_img_init_curr = result

      if j==0:
```

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View runtime logs

```
) & (warp_img_init_prev[:, :,

      warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step31:Done')

    return warp_img_init_prev

def final_steps_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
      input_img = images_right[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      warp_img_init_curr = result
```

```
        black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

        warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step32:Done')

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en
```

```
     Step1:Done
     Step2:Done
```

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_agast,xmax,xmin,yma
```

```
     Step31:Done
```

```
warp_imgs_all_agast = final_steps_right_union(warp_imgs_left, images_right_bgr_no_enhance,H_r
```

```
     Step32:Done
```

```
fig,ax =plt.subplots()
```

```
Text(0.5, 1.0, '120-Images Mosaic-AGAST')
```

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View runtime logs

```
fast = cv2.FastFeatureDetector_create(8)
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]))
```

```
100%|██████████| 51/51 [03:36<00:00,  4.25s/it]
100%|██████████| 50/50 [03:35<00:00,  4.31s/it]
```

```
#num_kps_sift = []
#num_kps_brisk = []
#num_kps_agast = []
```

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View runtime logs

```
num_kps_fast = []
#num_kps_freak = []
#num_kps_gftt = []
#num_kps_star = []

#for j in tqdm(keypoints_all_left_sift + keypoints_all_right_sift):
#  num_kps_sift.append(len(j))

#for j in tqdm(keypoints_all_left_brisk + keypoints_all_right_brisk):
  #num_kps_brisk.append(len(j))

#for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):
#  num_kps_agast.append(len(j))

#for j in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):
#  num_kps_kaze.append(len(j))

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

```
#for j in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
  #num_kps_orb.append(len(j))

#for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
#  num_kps_mser.append(len(j))

#for j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
#  num_kps_daisy.append(len(j))

#for j in tqdm(keypoints_all_left_surfsift + keypoints_all_right_surfsift):
#  num_kps_surfsift.append(len(j))

for j in tqdm(keypoints_all_left_fast + keypoints_all_right_fast):
  num_kps_fast.append(len(j))

#for j in tqdm(keypoints_all_left_freak + keypoints_all_right_freak):
  #num_kps_freak.append(len(j))

#for j in tqdm(keypoints_all_left_gftt + keypoints_all_right_gftt):
#  num_kps_gftt.append(len(j))

#for j in tqdm(keypoints_all_left_star + keypoints_all_right_star):
  #num_kps_star.append(len(j))
```

```
100%|██████████| 101/101 [00:00<00:00, 132672.94it/s]
```

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View runtime logs

```
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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
    return H, inliers


def compute_homography_fast_other(matched_pts1, matched_pts2):
    #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,
                                    0)
```

```
    inliers = inliers.flatten()
    return H, inliers


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_1.append((m[0].trainIdx, m[0].queryIdx))
```



```
  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])
  '''
  # 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, RANSACthresh=6)
  '''
```

```
  Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
  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")
```

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```
, RANSACthresh=6)
  #global inlier_matchset

  if disp==True:
    dispimg1=cv2.drawMatches(imgs[0], keypts[0], imgs[1], keypts[1], inlier_matchset, None,fl
    displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

  return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


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


print(left_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
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
  H_left_fast.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_right_fast
  H_right_fast.append(H_a)
  #num_matches.append(matches)
```



```
Robust matches 6995
```

```
 80%|████████  | 40/50 [08:46<02:07, 12.77s/it]
Number of matches 52357
Number of matches After Lowe's Ratio 5728
Number of Robust matches 3186


 82%|████████▏  | 41/50 [09:00<01:56, 12.94s/it]
Number of matches 48825
Number of matches After Lowe's Ratio 142
Number of Robust matches 60


 84%|████████▍  | 42/50 [09:12<01:42, 12.87s/it]
Number of matches 50151
Number of matches After Lowe's Ratio 4079
Number of Robust matches 3002


 86%|████████▌  | 43/50 [09:25<01:30, 12.95s/it]
Number of matches 52256
```

```
Number of matches After Lowe's Ratio 2704
Number of Robust matches 1896


 88%|████████▊ | 44/50 [09:38<01:17, 12.98s/it]
Number of matches 54121
Number of matches After Lowe's Ratio 1487
Number of Robust matches 1082


 90%|█████████ | 45/50 [09:52<01:06, 13.29s/it]
Number of matches 53815
Number of matches After Lowe's Ratio 3993
Number of Robust matches 3083


 92%|█████████▏ | 46/50 [10:06<00:53, 13.27s/it]
Number of matches 49698
Number of matches After Lowe's Ratio 2788
Number of Robust matches 2225


 94%|█████████▍ | 47/50 [10:18<00:39, 13.04s/it]
Number of matches 47704
Number of matches After Lowe's Ratio 12366
Number of Robust matches 9655


 96%|█████████▌| 48/50 [10:30<00:25, 12.75s/it]
Number of matches 49037
Number of matches After Lowe's Ratio 5760
```

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View runtime logs

```
    #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),axi

                                                                          .5)
                                                                          .5)

                                                                        translate

    print('Step2:Done')


    return xmax,xmin,ymax,ymin,t,h,w,Ht


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []


    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))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]
```

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View runtime logs

```
        warp_imgs_left.append(result)

    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    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_imgs_right.append(result)

    print('Step32:Done')

    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
    #Union
```



```
    #warp_final_all=[]

    for j,warp_img in enumerate(warp_images_all):
      if j==len(warp_images_all)-1:
        break
      black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

      warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

      #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
      #warp_img_init = warp_final
      #warp_final_all.append(warp_final)

    print('Step4:Done')


    return warp_img_init
```

```
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
      input_img = images_left[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      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[:, :,

      warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step31:Done')

    return warp_img_init_prev
```



```
,xmax,xmin,ymax,ymin,t,h,w,Ht):

        H_trans = Ht@H
      else:
        H_trans = H_trans@H
      input_img = images_right[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      warp_img_init_curr = result

      black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

      warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step32:Done')

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en
```

```
Step1:Done
Step2:Done
```

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_fast,xmax,xmin,ymax
```

```
warp_imgs_all_fast = final_steps_right_union(warp_imgs_left, images_right_bgr_no_enhance,H_ri
```

```
fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_fast , cv2.COLOR_BGR2RGB))
ax.set_title('120-Images Mosaic-FAST')
```

```
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):
```

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View runtime logs

```
or 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%|██████████| 56/56 [00:13<00:00,  4.05it/s]
100%|██████████| 55/55 [00:13<00:00,  3.99it/s]
```

```
#num_kps_sift = []
#num_kps_brisk = []
#num_kps_agast = []
#num_kps_kaze = []
#num_kps_akaze = []
#num_kps_orb = []
#num_kps_mser = []
#num_kps_daisy = []
```

```
#num_kps_surfsift = []
#num_kps_fast = []
#num_kps_freak = []
num_kps_gftt = []
#num_kps_star = []

#for j in tqdm(keypoints_all_left_sift + keypoints_all_right_sift):
#  num_kps_sift.append(len(j))

#for j in tqdm(keypoints_all_left_brisk + keypoints_all_right_brisk):
  #num_kps_brisk.append(len(j))

#for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):
#  num_kps_agast.append(len(j))

#for j in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):
#  num_kps_kaze.append(len(j))

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

#for j in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
  #num_kps_orb.append(len(j))

#for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
#  num_kps_mser.append(len(j))

#for j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
```

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View runtime logs

```
#for j in tqdm(keypoints_all_left_fast + keypoints_all_right_fast):
#  num_kps_fast.append(len(j))

#for j in tqdm(keypoints_all_left_freak + keypoints_all_right_freak):
  #num_kps_freak.append(len(j))

for j in tqdm(keypoints_all_left_gftt + keypoints_all_right_gftt):
  num_kps_gftt.append(len(j))

#for j in tqdm(keypoints_all_left_star + keypoints_all_right_star):
  #num_kps_star.append(len(j))
```

```
100%|██████████| 111/111 [00:00<00:00, 47405.33it/s]
```

```
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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
    return H, inliers


def compute_homography_fast_other(matched_pts1, matched_pts2):
    #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,
                                    0)
    inliers = inliers.flatten()
    return H, inliers


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])
```



```
  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_1.append((m[0].trainIdx, m[0].queryIdx))
        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])
  matches_idx = np.array([m.trainIdx for m in matches_4])
  imm2_pts = np.array([keypts[1][idx].pt for idx in matches_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, RANSACthresh=6)
'''



Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
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:
```

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```
  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,fl
```

```
    displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

  return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


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


print(left_files_path)
```

```
    ['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0059.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
    ['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0059.JPG', '/content/drive/MyDrive
```

```
H_left_gftt = []
H_right_gftt = []

num_matches_gftt = []
num_good_matches_gftt = []

for j in tqdm(range(len(images_left))):
```



```
:-1],keypoints_all_left_gftt[j
  #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_right_gftt
  H_right_gftt.append(H_a)
  #num_matches.append(matches)
  #num_good_matches.append(gd_matches)
```

```
      2%|▌          | 1/56 [00:00<00:08,  6.76it/s]
    Number of matches 1000
    Number of matches After Lowe's Ratio 32
    Number of Robust matches 5



    Number of matches 1000
```

```
Number of matches After Lowe's Ratio 306
Number of Robust matches 187


  7%|▋         | 4/56 [00:00<00:06,  7.89it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 165
Number of Robust matches 94



Number of matches 1000
Number of matches After Lowe's Ratio 180
Number of Robust matches 97


 11%|█         | 6/56 [00:00<00:05,  8.35it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 128
Number of Robust matches 61



Number of matches 1000
Number of matches After Lowe's Ratio 208
Number of Robust matches 124


 12%|█▎        | 7/56 [00:00<00:05,  8.78it/s]
Number of matches 1000
```

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```
Number of matches After Lowe's Ratio 157
Number of Robust matches 117


 18%|█▊        | 10/56 [00:01<00:05,  8.84it/s]
Number of matches 1000
Number of matches After Lowe's Ratio 278
Number of Robust matches 238



Number of matches 1000
Number of matches After Lowe's Ratio 75
Number of Robust matches 25
```

```
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):
```



```
      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),axi

    [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
```

```
def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []


    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))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)

    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    for j,H in enumerate(H_right):
```



```
(xmax-xmin, ymax-ymin))

      warp_imgs_right.append(result)

    print('Step32:Done')

    return warp_imgs_right

def final_steps_union(warp_imgs_left,warp_imgs_right):
    #Union

    warp_images_all = warp_imgs_left + warp_imgs_right

    warp_img_init = warp_images_all[0]



    #warp_final_all=[]

    for j,warp_img in enumerate(warp_images_all):
```

```
      if j==len(warp_images_all)-1:
        break
      black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

      warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]

      #warp_final = np.maximum(warp_img_init,warp_images_all[j+1])
      #warp_img_init = warp_final
      #warp_final_all.append(warp_final)

    print('Step4:Done')


    return warp_img_init


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
      input_img = images_left[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')
```



```
ns, dsize = (xmax-xmin, ymax-ym

        warp_img_init_prev = result
        continue

      black_pixels = np.where((warp_img_init_prev[:, :, 0] == 0) & (warp_img_init_prev[:, :,

      warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step31:Done')

    return warp_img_init_prev

def final_steps_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
      input_img = images_right[j+1]
```

```
        result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

        cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
        warp_img_init_curr = result

        black_pixels = np.where((warp_img_prev[:, :, 0] == 0) & (warp_img_prev[:, :, 1] == 0) &

        warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step32:Done')

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en
```

```
     Step1:Done
     Step2:Done
```

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_gftt,xmax,xmin,ymax


warp_imgs_all_gftt = final_steps_right_union(warp_imgs_left, images_right_bgr_no_enhance,H_ri


fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_gftt , cv2.COLOR_BGR2RGB))
```

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```
Threshl=40;
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]))
```

```
  0%|          | 0/51 [00:00<?, ?it/s]
  2%|▏         | 1/51 [00:01<00:58,  1.16s/it]
  4%|▍         | 2/51 [00:01<00:49,  1.00s/it]
  6%|▌         | 3/51 [00:02<00:45,  1.06it/s]
  8%|▊         | 4/51 [00:03<00:39,  1.20it/s]
 10%|▉         | 5/51 [00:03<00:37,  1.24it/s]
 12%|█▏        | 6/51 [00:04<00:35,  1.26it/s]
 14%|█▎        | 7/51 [00:05<00:36,  1.22it/s]
 16%|█▌        | 8/51 [00:06<00:36,  1.19it/s]
 18%|█▊        | 9/51 [00:07<00:35,  1.19it/s]
 20%|█▉        | 10/51 [00:08<00:35,  1.17it/s]
 22%|██▏       | 11/51 [00:08<00:33,  1.19it/s]
 24%|██▎       | 12/51 [00:09<00:32,  1.18it/s]
 25%|██▌       | 13/51 [00:10<00:32,  1.16it/s]
 27%|██▋       | 14/51 [00:11<00:32,  1.16it/s]
 29%|██▉       | 15/51 [00:12<00:30,  1.16it/s]
 31%|███       | 16/51 [00:13<00:29,  1.18it/s]
 33%|███▎      | 17/51 [00:14<00:30,  1.13it/s]
```

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```
 47%|████▋     | 24/51 [00:20<00:25,  1.05it/s]
 49%|████▉     | 25/51 [00:21<00:24,  1.06it/s]
 51%|█████     | 26/51 [00:22<00:22,  1.11it/s]
 53%|█████▎    | 27/51 [00:23<00:20,  1.15it/s]
 55%|█████▍    | 28/51 [00:24<00:19,  1.18it/s]
 57%|█████▋    | 29/51 [00:24<00:18,  1.20it/s]
 59%|█████▉    | 30/51 [00:25<00:18,  1.13it/s]
 61%|██████    | 31/51 [00:27<00:20,  1.01s/it]
 63%|██████▎   | 32/51 [00:28<00:20,  1.10s/it]
 65%|██████▍   | 33/51 [00:29<00:20,  1.14s/it]
 67%|██████▋   | 34/51 [00:30<00:19,  1.13s/it]
 69%|██████▊   | 35/51 [00:31<00:17,  1.07s/it]
 71%|███████   | 36/51 [00:32<00:14,  1.01it/s]
 73%|███████▎  | 37/51 [00:33<00:13,  1.04it/s]
 75%|███████▍  | 38/51 [00:34<00:12,  1.05it/s]
 76%|███████▋  | 39/51 [00:35<00:11,  1.04it/s]
 78%|███████▊  | 40/51 [00:36<00:10,  1.04it/s]
 80%|███████▉  | 41/51 [00:37<00:09,  1.01it/s]
 82%|████████▏ | 42/51 [00:38<00:08,  1.07it/s]
 84%|████████▎ | 43/51 [00:39<00:07,  1.13it/s]
 86%|████████▌ | 44/51 [00:39<00:05,  1.17it/s]
```

```
 88%|████████▊ | 45/51 [00:40<00:05,  1.19it/s]
 90%|█████████ | 46/51 [00:41<00:03,  1.27it/s]
 92%|█████████▏| 47/51 [00:42<00:03,  1.29it/s]
 94%|█████████▍| 48/51 [00:42<00:02,  1.30it/s]
 96%|█████████▌| 49/51 [00:43<00:01,  1.30it/s]
 98%|█████████▊| 50/51 [00:44<00:00,  1.31it/s]
100%|██████████| 51/51 [00:44<00:00,  1.13it/s]

  0%|          | 0/50 [00:00<?, ?it/s]
  2%|▏         | 1/50 [00:00<00:43,  1.13it/s]
  4%|▍         | 2/50 [00:01<00:41,  1.17it/s]
  6%|▌         | 3/50 [00:02<00:39,  1.20it/s]
  8%|▊         | 4/50 [00:03<00:36,  1.26it/s]
```

```
#num_kps_sift = []
#num_kps_brisk = []
#num_kps_agast = []
#num_kps_kaze = []
#num_kps_akaze = []
#num_kps_orb = []
#num_kps_mser = []
#num_kps_daisy = []
#num_kps_surfsift = []
#num_kps_fast = []
num_kps_freak = []
#num_kps_gftt = []
#num_kps_star = []
```

```
...ift):
```

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```
...brisk):
```

```
#for j in tqdm(keypoints_all_left_agast + keypoints_all_right_agast):
#  num_kps_agast.append(len(j))

#for j in tqdm(keypoints_all_left_kaze + keypoints_all_right_kaze):
#  num_kps_kaze.append(len(j))

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

#for j in tqdm(keypoints_all_left_orb + keypoints_all_right_orb):
  #num_kps_orb.append(len(j))

#for j in tqdm(keypoints_all_left_mser + keypoints_all_right_mser):
#  num_kps_mser.append(len(j))

#for j in tqdm(keypoints_all_left_daisy + keypoints_all_right_daisy):
#  num_kps_daisy.append(len(j))

#for j in tqdm(keypoints_all_left_surfsift + keypoints_all_right_surfsift):
```

```
#  num_kps_surfsift.append(len(j))

#for j in tqdm(keypoints_all_left_fast + keypoints_all_right_fast):
#  num_kps_fast.append(len(j))

for j in tqdm(keypoints_all_left_freak + keypoints_all_right_freak):
  num_kps_freak.append(len(j))

#for j in tqdm(keypoints_all_left_gftt + keypoints_all_right_gftt):
 # num_kps_gftt.append(len(j))

#for j in tqdm(keypoints_all_left_star + keypoints_all_right_star):
  #num_kps_star.append(len(j))
```

```
100%|██████████| 101/101 [00:00<00:00, 377562.12it/s]
```

```
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, ransacReprojThreshold =thresh)
    inliers = inliers.flatten()
    return H, inliers
```

Your session crashed after using all available RAM. If you are interested in access to high-RAM runtimes, you may want to check out Colab Pro.

View runtime logs

```
    # Estimate the homography between the matches using RANSAC
    H, inliers = cv2.findHomography(matched_pts1,
                                    matched_pts2,
                                    0)
    inliers = inliers.flatten()
    return H, inliers


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_1.append((m[0].trainIdx, m[0].queryIdx))
      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])
matches_idx = np.array([m.trainIdx for m in matches_4])
imm2_pts = np.array([keypts[1][idx].pt for idx in matches_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))
```

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```
  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, RANSACthresh=6)
'''


Hn,inliers = compute_homography_fast(imm1_pts,imm2_pts,thresh)
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,fl
    displayplot(dispimg1,'Robust Matching between Reference Image and Right Image ')

  return Hn/Hn[2,2], len(matches_lf1_lf), len(inlier_matchset)


from functools import partial
```

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```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
print(right_files_path)
```

```
['/content/drive/MyDrive/RGB-img/img/IX-11-01917_0004_0054.JPG', '/content/drive/MyDrive
```

```
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[
    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_right_frea
    H_right_freak.append(H_a)
    num_matches_freak.append(matches)
    num_good_matches_freak.append(gd_matches)
```

```
  2%|▏          | 1/51 [00:02<02:12,  2.66s/it]
Number of matches 18890
Number of matches After Lowe's Ratio 1794
Number of Robust matches 447


  4%|▍          | 2/51 [00:04<02:00,  2.45s/it]
Number of matches 24513
Number of matches After Lowe's Ratio 2268
Number of Robust matches 837


  6%|▌          | 3/51 [00:06<01:55,  2.41s/it]
Number of matches 18630
```



```
Number of matches After Lowe's Ratio 2795
Number of Robust matches 1189


 10%|▉          | 5/51 [00:11<01:43,  2.26s/it]
Number of matches 22263
Number of matches After Lowe's Ratio 2739
Number of Robust matches 1267


 12%|█          | 6/51 [00:13<01:43,  2.31s/it]
Number of matches 25590
Number of matches After Lowe's Ratio 2787
Number of Robust matches 1110


 14%|█▏         | 7/51 [00:16<01:45,  2.39s/it]
Number of matches 25233
Number of matches After Lowe's Ratio 3367
Number of Robust matches 1680
```

```
 16%|█         | 8/51 [00:18<01:45,  2.44s/it]
Number of matches 24546
Number of matches After Lowe's Ratio 2881
Number of Robust matches 1078


 18%|██        | 9/51 [00:21<01:44,  2.49s/it]
Number of matches 23743
Number of matches After Lowe's Ratio 2836
Number of Robust matches 1296


 20%|██        | 10/51 [00:23<01:42,  2.49s/it]
Number of matches 25436
Number of matches After Lowe's Ratio 2994
Number of Robust matches 1281
```

```
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)
```

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```
be(-1, 1, 2)


      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:
```

```
      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),axi

    [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


def final_steps_left(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_left = []
```

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```
      H_trans = H_trans@H
      result = cv2.warpPerspective(images_left[j+1], H_trans, (xmax-xmin, ymax-ymin))

      if j==0:
        result[t[1]:h+t[1], t[0]:w+t[0]] = images_left[0]

      warp_imgs_left.append(result)

    print('Step31:Done')

    return warp_imgs_left

def final_steps_right(images_left,images_right,H_left,H_right,xmax,xmin,ymax,ymin,t,h,w,Ht):

    warp_imgs_right = []

    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_imgs_right.append(result)

      print('Step32:Done')

      return warp_imgs_right

  def final_steps_union(warp_imgs_left,warp_imgs_right):
      #Union

      warp_images_all = warp_imgs_left + warp_imgs_right

      warp_img_init = warp_images_all[0]



      #warp_final_all=[]

      for j,warp_img in enumerate(warp_images_all):
        if j==len(warp_images_all)-1:
          break
        black_pixels = np.where((warp_img_init[:, :, 0] == 0) & (warp_img_init[:, :, 1] == 0) &

        warp_img_init[black_pixels] = warp_images_all[j+1][black_pixels]
```



```
      return warp_img_init


  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
        input_img = images_left[j+1]
        result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

        cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
        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[:, :,

      warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('Step31:Done')

    return warp_img_init_prev

def final_steps_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
      input_img = images_right[j+1]
      result = np.zeros((ymax-ymin,xmax-xmin,3),dtype='uint8')

      cv2.warpPerspective(src = np.uint8(input_img), M = H_trans, dsize = (xmax-xmin, ymax-ym
      warp_img_init_curr = result

                                                                                (warp_img_prev[:, :, 1] == 0) &

                                                                                ixels]

    return warp_img_prev


xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_no_en

     Step1:Done
     Step2:Done


warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_freak,xmax,xmin,yma


warp_imgs_all_freak = final_steps_right_union(warp_imgs_left, images_right_bgr_no_enhance,H_r


fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_freak , cv2.COLOR_BGR2RGB))
ax.set_title('120-Images Mosaic-FREAK')
```