In [1]:

```
!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-p
ackages (3.4.2.17)
Requirement already satisfied: numpy>=1.14.5 in /usr/local/lib/python3.7/dist-packages (f
rom opencv-python==3.4.2.17) (1.19.5)
Requirement already satisfied: opencv-contrib-python==3.4.2.17 in /usr/local/lib/python3.
7/dist-packages (3.4.2.17)
Requirement already satisfied: numpy>=1.14.5 in /usr/local/lib/python3.7/dist-packages (f
rom opencv-contrib-python==3.4.2.17) (1.19.5)

In [2]:

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

In [3]:

```
!pip install torchsummary
```

Requirement already satisfied: torchsummary in /usr/local/lib/python3.7/dist-packages (1.
5.1)

In [4]:

```
import numpy as np

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

In [5]:

```
class Image:
```

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

inliner_matchset = []
def features_matching(a,keypointlength,threshold):
    bestmatch = np.empty((keypointlength), dtype=np.int16)
    img1index = np.empty((keypointlength),dtype=np.init16)
    distance = np.empty((keypointlength))
    index =0
    for j in range(0,keypointlength):
        x=a[j]
        listx = x.tolist()
        x.sort()
        minval1=x[0]
        minval2=x[1]
        itemindex1 = listx.index(minval1)
        itemindex2 = listx.index(minval2)
        ratio = minval1/minval2

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

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

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

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

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

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

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

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

In [6]:

```
from google.colab import files
files.upload()
```

Choose File **No file selected**

Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

Saving kaggle.json to kaggle.json

Out[6]:

{'kaggle.json': b'{"username":"raj10gupta","key":"da9c6c2bb369bf5c5c20cf514b90753b"}'}

In [7]:

```
!mkdir -p  ~/.kaggle
!cp kaggle.json ~/.kaggle/

!chmod 600 ~/.kaggle/kaggle.json
```

In [8]:

```
!kaggle datasets download -d raj10gupta/uni-campus-dataset
```

```
Downloading uni-campus-dataset.zip to /content
100% 4.34G/4.34G [01:25<00:00, 45.0MB/s]
100% 4.34G/4.34G [01:25<00:00, 54.6MB/s]
```

In [9]:

```
from zipfile import ZipFile
file_name = 'uni-campus-dataset.zip'

with ZipFile(file_name,'r') as zip:
  zip.extractall()
  print('Done')
```

Done

In [6]:

```
files_all = os.listdir('/content/RGB-img/img/')
files_all.sort()

folder_path = '/content/RGB-img/img/'
left_files_path_rev = []
right_files_path = []
for file in files_all[:51]:
    left_files_path_rev.append(folder_path + file)
```

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


for file in files_all[51:110]:
    right_files_path.append(folder_path + file)
```

In [7]:

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


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


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

```
100%|████████| 51/51 [00:50<00:00,  1.01it/s]
100%|████████| 59/59 [00:58<00:00,  1.01it/s]
```

In [8]:

```
images_left_bgr_no_enhance = []

images_right_bgr_no_enhance = []

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

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

```
100%|████████| 51/51 [00:18<00:00,  2.75it/s]
100%|████████| 59/59 [00:21<00:00,  2.72it/s]
```

In [9]:

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

In [ ]:

```
orb = cv2.ORB_create(5000)
```

```python
keypoints_all_left_orb = []
descriptors_all_left_orb = []
points_all_left_orb=[]

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

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

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

```
100%|██████████| 51/51 [00:08<00:00,  5.70it/s]
100%|██████████| 59/59 [00:09<00:00,  6.07it/s]
```

In [11]:

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

```
fatal: destination path 'SuperPointPretrainedNetwork' already exists and is not an empty
directory.
```

In [12]:

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

In [13]:

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

In [14]:

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


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

    def forward(self,x):
        x = self.relu(self.conv1a(x))
        x = self.relu(self.conv1b(x))
        x = self.pool(x)
        x = self.relu(self.conv2a(x))
```

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


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

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

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


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

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

    def run(self,img):
```

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


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

        return heatmap,coarse_desc

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

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

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

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

In [ ]:

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

```
100%|██████████| 110/110 [00:00<00:00, 101512.31it/s]
```

In [18]:

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

In [19]:

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

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

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

    inlier_matchset = np.array(matches_4)[inliers.astype(bool)].tolist()
    print("Number of Robust matches",len(inlier_matchset))
```

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

In [20]:

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

In [ ]:

```
H_left_orb = []
H_right_orb = []

num_matches_orb = []
num_good_matches_orb = []

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

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

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

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

```
  4%|█              | 2/51 [00:00<00:08,  5.45it/s]
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 397
```

```
Number of Robust matches 253



Number of matches 5000
Number of matches After Lowe's Ratio 373
Number of Robust matches 196


  8%|█         | 4/51 [00:00<00:08,  5.56it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 391
Number of Robust matches 254



Number of matches 5000
Number of matches After Lowe's Ratio 465
Number of Robust matches 357


 12%|█         | 6/51 [00:01<00:08,  5.48it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 377
Number of Robust matches 263



Number of matches 5000
Number of matches After Lowe's Ratio 507
Number of Robust matches 373


 16%|██        | 8/51 [00:01<00:07,  5.57it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 432
Number of Robust matches 282



Number of matches 5000
Number of matches After Lowe's Ratio 472
Number of Robust matches 330


 20%|██        | 10/51 [00:01<00:07,  5.60it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 568
Number of Robust matches 382



Number of matches 5000
Number of matches After Lowe's Ratio 436
Number of Robust matches 256


 24%|██        | 12/51 [00:02<00:08,  4.84it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 320
Number of Robust matches 163
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 397
Number of Robust matches 246


 27%|██▊         | 14/51 [00:02<00:07,  5.12it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 400
Number of Robust matches 214



Number of matches 5000
Number of matches After Lowe's Ratio 337
Number of Robust matches 202


 31%|███         | 16/51 [00:03<00:06,  5.29it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 335
Number of Robust matches 186



Number of matches 5000
Number of matches After Lowe's Ratio 345
Number of Robust matches 147


 35%|███▌        | 18/51 [00:03<00:06,  5.32it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 395
Number of Robust matches 216



Number of matches 5000
Number of matches After Lowe's Ratio 329
Number of Robust matches 157


 37%|███▋        | 19/51 [00:03<00:06,  5.30it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 275
Number of Robust matches 96



Number of matches 5000
Number of matches After Lowe's Ratio 293

 39%|███▉        | 20/51 [00:03<00:05,  5.27it/s]

Number of Robust matches 101


Number of matches 5000
Number of matches After Lowe's Ratio 190

 41%|████▏       | 21/51 [00:04<00:06,  4.96it/s]

Number of Robust matches 45


Number of matches 5000
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 153
 45%|█████       | 23/51 [00:04<00:05,  4.90it/s]
Number of Robust matches 11


Number of matches 5000
Number of matches After Lowe's Ratio 342
Number of Robust matches 144


 49%|██████      | 25/51 [00:04<00:04,  5.22it/s]
Number of matches 5000
Number of matches After Lowe's Ratio 418
Number of Robust matches 195


Number of matches 5000
Number of matches After Lowe's Ratio 319
Number of Robust matches 139


 51%|██████      | 26/51 [00:04<00:04,  5.23it/s]
Number of matches 5000
Number of matches After Lowe's Ratio 297
Number of Robust matches 129


Number of matches 5000
Number of matches After Lowe's Ratio 273
 53%|██████▏     | 27/51 [00:05<00:04,  5.08it/s]
Number of Robust matches 70


Number of matches 5000
Number of matches After Lowe's Ratio 342
 57%|██████▊     | 29/51 [00:05<00:04,  4.95it/s]
Number of Robust matches 71


Number of matches 5000
Number of matches After Lowe's Ratio 263
Number of Robust matches 68


 61%|███████▍    | 31/51 [00:05<00:03,  5.26it/s]
Number of matches 5000
Number of matches After Lowe's Ratio 324
Number of Robust matches 177


Number of matches 5000
Number of matches After Lowe's Ratio 402
Number of Robust matches 246
```

```
 65%|████████        | 33/51 [00:06<00:03,  5.43it/s]
```

Number of matches 5000
Number of matches After Lowe's Ratio 514
Number of Robust matches 343

Number of matches 5000
Number of matches After Lowe's Ratio 520
Number of Robust matches 374

```
 69%|████████        | 35/51 [00:06<00:02,  5.58it/s]
```

Number of matches 5000
Number of matches After Lowe's Ratio 497
Number of Robust matches 310

Number of matches 5000
Number of matches After Lowe's Ratio 489
Number of Robust matches 300

```
 73%|████████        | 37/51 [00:07<00:02,  5.56it/s]
```

Number of matches 5000
Number of matches After Lowe's Ratio 420
Number of Robust matches 234

Number of matches 5000
Number of matches After Lowe's Ratio 336
Number of Robust matches 162

```
 76%|████████        | 39/51 [00:07<00:02,  5.58it/s]
```

Number of matches 5000
Number of matches After Lowe's Ratio 307
Number of Robust matches 142

Number of matches 5000
Number of matches After Lowe's Ratio 572
Number of Robust matches 423

```
 80%|████████        | 41/51 [00:07<00:01,  5.63it/s]
```

Number of matches 5000
Number of matches After Lowe's Ratio 521
Number of Robust matches 389

Number of matches 5000
Number of matches After Lowe's Ratio 333
Number of Robust matches 202

```
 84%|████████        | 43/51 [00:08<00:01,  5.02it/s]
```

Number of matches 5000
Number of matches After Lowe's Ratio 340

```
Number of Robust matches 181


Number of matches 5000
Number of matches After Lowe's Ratio 442
Number of Robust matches 269


  88%|████████▊ | 45/51 [00:08<00:01,  5.32it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 312
Number of Robust matches 181


Number of matches 5000
Number of matches After Lowe's Ratio 368
Number of Robust matches 200


  92%|█████████▏| 47/51 [00:08<00:00,  5.41it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 356
Number of Robust matches 155


Number of matches 5000
Number of matches After Lowe's Ratio 392
Number of Robust matches 156


  94%|█████████▍| 48/51 [00:09<00:00,  5.24it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 318
Number of Robust matches 94


Number of matches 5000
Number of matches After Lowe's Ratio 413

  96%|█████████▌| 49/51 [00:09<00:00,  5.28it/s]

Number of Robust matches 143


Number of matches 5000
Number of matches After Lowe's Ratio 196

  98%|█████████▊| 50/51 [00:09<00:00,  5.24it/s]
   2%|▏         | 1/59 [00:00<00:10,  5.43it/s]

Number of Robust matches 22


Number of matches 5000
Number of matches After Lowe's Ratio 373
Number of Robust matches 233


   5%|▌         | 3/59 [00:00<00:10,  5.55it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 242
```

Number of Matches After Lowe's Ratio 212
Number of Robust matches 97

Number of matches 5000
Number of matches After Lowe's Ratio 353
Number of Robust matches 197


```
  8%|▌          | 5/59 [00:00<00:09,  5.51it/s]
```

Number of matches 5000
Number of matches After Lowe's Ratio 379
Number of Robust matches 166

Number of matches 5000
Number of matches After Lowe's Ratio 394
Number of Robust matches 202


```
 10%|▌          | 6/59 [00:01<00:09,  5.52it/s]
```

Number of matches 5000
Number of matches After Lowe's Ratio 373
Number of Robust matches 180

Number of matches 5000
Number of matches After Lowe's Ratio 147

```
 12%|▌          | 7/59 [00:01<00:10,  5.16it/s]
```

Number of Robust matches 6

Number of matches 5000
Number of matches After Lowe's Ratio 206

```
 14%|▌          | 8/59 [00:01<00:10,  4.94it/s]
```

Number of Robust matches 30

Number of matches 5000
Number of matches After Lowe's Ratio 175

```
 17%|█          | 10/59 [00:01<00:09,  4.96it/s]
```

Number of Robust matches 38

Number of matches 5000
Number of matches After Lowe's Ratio 301
Number of Robust matches 137


```
 20%|█▌         | 12/59 [00:02<00:08,  5.29it/s]
```

Number of matches 5000
Number of matches After Lowe's Ratio 507
Number of Robust matches 331

Number of matches 5000

```
Number of matches After Lowe's Ratio 501
Number of Robust matches 327


 22%|██        | 13/59 [00:02<00:08,  5.36it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 331
Number of Robust matches 194


Number of matches 5000
Number of matches After Lowe's Ratio 221

 25%|██        | 15/59 [00:02<00:08,  5.39it/s]

Number of Robust matches 64


Number of matches 5000
Number of matches After Lowe's Ratio 432
Number of Robust matches 300


 29%|███       | 17/59 [00:03<00:07,  5.39it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 301
Number of Robust matches 151


Number of matches 5000
Number of matches After Lowe's Ratio 535
Number of Robust matches 386


 32%|███       | 19/59 [00:03<00:07,  5.56it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 630
Number of Robust matches 491


Number of matches 5000
Number of matches After Lowe's Ratio 388
Number of Robust matches 267


 36%|███       | 21/59 [00:03<00:06,  5.60it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 497
Number of Robust matches 363


Number of matches 5000
Number of matches After Lowe's Ratio 352
Number of Robust matches 210


 37%|███       | 22/59 [00:04<00:06,  5.54it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 495
Number of Robust matches 320
```

Number of Robust matches 320

41%|███ | 24/59 [00:04<00:06, 5.10it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 429
Number of Robust matches 246

Number of matches 5000
Number of matches After Lowe's Ratio 462
Number of Robust matches 283

44%|███▊ | 26/59 [00:04<00:06, 5.35it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 403
Number of Robust matches 252

Number of matches 5000
Number of matches After Lowe's Ratio 359
Number of Robust matches 158

47%|████▏ | 28/59 [00:05<00:05, 5.43it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 396
Number of Robust matches 167

Number of matches 5000
Number of matches After Lowe's Ratio 412
Number of Robust matches 195

51%|████▌ | 30/59 [00:05<00:05, 5.42it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 437
Number of Robust matches 196

Number of matches 5000
Number of matches After Lowe's Ratio 397
Number of Robust matches 173

53%|████▊ | 31/59 [00:05<00:05, 5.48it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 403
Number of Robust matches 225

Number of matches 5000
Number of matches After Lowe's Ratio 124

54%|████▉ | 32/59 [00:06<00:05, 5.18it/s]

Number of Robust matches 7

```
Number of matches 5000
Number of matches After Lowe's Ratio 215
```

```
 56%|███████       | 33/59 [00:06<00:05,  4.95it/s]
```

```
Number of Robust matches 43
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 128
```

```
 58%|███████       | 34/59 [00:06<00:05,  4.79it/s]
```

```
Number of Robust matches 6
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 230
```

```
 61%|███████       | 36/59 [00:06<00:04,  4.99it/s]
```

```
Number of Robust matches 57
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 389
Number of Robust matches 210
```

```
 64%|████████      | 38/59 [00:07<00:04,  5.19it/s]
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 404
Number of Robust matches 163
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 370
Number of Robust matches 160
```

```
 66%|████████      | 39/59 [00:07<00:03,  5.19it/s]
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 303
Number of Robust matches 94
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 301
```

```
 69%|████████      | 41/59 [00:07<00:03,  5.09it/s]
```

```
Number of Robust matches 71
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 410
Number of Robust matches 165
```

```
 73%|█████████     | 43/59 [00:08<00:03,  5.26it/s]
```

```
Number of matches 5000
```

Number of matches 5000
Number of matches After Lowe's Ratio 245
Number of Robust matches 75

Number of matches 5000
Number of matches After Lowe's Ratio 376
Number of Robust matches 213

 76%|████████▏ | 45/59 [00:08<00:02, 5.38it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 330
Number of Robust matches 124

Number of matches 5000
Number of matches After Lowe's Ratio 307
Number of Robust matches 136

 80%|████████▋ | 47/59 [00:08<00:02, 5.49it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 298
Number of Robust matches 186

Number of matches 5000
Number of matches After Lowe's Ratio 550
Number of Robust matches 355

 83%|█████████ | 49/59 [00:09<00:01, 5.50it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 417
Number of Robust matches 287

Number of matches 5000
Number of matches After Lowe's Ratio 662
Number of Robust matches 506

 86%|█████████▍ | 51/59 [00:09<00:01, 5.52it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 459
Number of Robust matches 280

Number of matches 5000
Number of matches After Lowe's Ratio 598
Number of Robust matches 407

 90%|█████████▊ | 53/59 [00:10<00:01, 5.49it/s]

Number of matches 5000
Number of matches After Lowe's Ratio 300
Number of Robust matches 172

```
Number of matches 5000
Number of matches After Lowe's Ratio 397
Number of Robust matches 233
```

 93%|████████ | 55/59 [00:10<00:00, 5.05it/s]

```
Number of matches 5000
Number of matches After Lowe's Ratio 365
Number of Robust matches 219
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 597
Number of Robust matches 421
```

 97%|█████████ | 57/59 [00:10<00:00, 5.20it/s]

```
Number of matches 5000
Number of matches After Lowe's Ratio 396
Number of Robust matches 258
```

```
Number of matches 5000
Number of matches After Lowe's Ratio 541
Number of Robust matches 371
```

 98%|█████████ | 58/59 [00:11<00:00, 5.33it/s]

```
Number of matches 5000
Number of matches After Lowe's Ratio 469
Number of Robust matches 288
```

RAM Crashed here after 110 images for orb

In [22]:

```python
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:
```

```python
            H_trans = H_left[j]
        else:
            H_trans = H_trans@H_left[j]
        pts_ = cv2.perspectiveTransform(pts, H_trans)
        pts_left_transformed.append(pts_)

    for j,pts in enumerate(pts_right):
        if j==0:
            H_trans = H_right[j]
        else:
            H_trans = H_trans@H_right[j]
        pts_ = cv2.perspectiveTransform(pts, H_trans)
        pts_right_transformed.append(pts_)


    print('Step1:Done')


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

    pts_concat = np.concatenate((pts_centre,np.concatenate(np.array(pts_left_transformed
),axis=0),np.concatenate(np.array(pts_right_transformed),axis=0)), axis=0)

    [xmin, ymin] = np.int32(pts_concat.min(axis=0).ravel() - 0.5)
    [xmax, ymax] = np.int32(pts_concat.max(axis=0).ravel() + 0.5)
    t = [-xmin, -ymin]
    Ht = np.array([[1, 0, t[0]], [0, 1, t[1]], [0, 0, 1]])  # translate

    print('Step2:Done')


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

In [23]:

```python
def final_steps_left_union(images_left,H_left,xmax,xmin,ymax,ymin,t,h,w,Ht):
    for j,H in enumerate(H_left):
        if j==  0:
            H_trans = Ht@H

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

        if j == 0:
            result[t[1]:h+t[1],t[0]:w+t[0]] = images_left[0]
            warp_img_init_prev = result
            continue
        black_pixels = np.where((warp_img_init_prev[:,:,0]==0)&(warp_img_init_prev[:,:,1
]==0)&(warp_img_init_prev[:,:,2]==0))
        warp_img_init_prev[black_pixels] = warp_img_init_curr[black_pixels]

    print('step31:Done')
    return warp_img_init_prev

def final_step_right_union(warp_img_prev,images_right,H_right,xmax,xmin,ymax,ymin,t,h,w,
Ht):
    for j,H in enumerate(H_right):
        if j==  0:
            H_trans = Ht@H
        else:
            H_trans = H_trans@H
        result =  cv2.warpPerspective(images_right[j+1],H_trans,(xmax-xmin,ymax-ymin))
        warp_img_init_curr = result


        black_pixels = np.where((warp_img_prev[:,:,0]==0)&(warp_img_prev[:,:,1]==0)&(war
p_img_prev[:,:,2]==0))
        warp_img_prev[black_pixels] = warp_img_init_curr[black_pixels]
```

```
        print('step32:Done')
        return warp_img_prev
```

In [ ]:

```
xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_orb,H_right_orb)
```

```
---------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-27-ea1a3da49134> in <module>()
----> 1 xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_ri
ght_bgr_no_enhance,H_left_orb,H_right_orb)

NameError: name 'H_left_orb' is not defined
```

In [ ]:

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_orb,xmax,xmin,y
max,ymin,t,h,w,Ht)
```

In [ ]:

```
warp_imgs_all_orb = final_step_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_r
ight_orb,xmax,xmin,ymax,ymin,t,h,w,Ht)
```

In [ ]:

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

ROOTSIFT 110 images

In [ ]:

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

In [ ]:

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

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

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

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-2-fe73d8c8fcd1> in <module>()
----> 1 sift = cv2.xfeatures2d.SIFT_create()
      2 rootsift = RootSIFT()
      3 keypoints_all_left_rootsift = []
      4 descriptors_all_left_rootsift = []
      5 points_all_left_rootsift=[]

NameError: name 'cv2' is not defined
```

In [ ]:

```python
num_kps_rootsift = []
for j  in tqdm(keypoints_all_left_rootsift + keypoints_all_right_rootsift):
    num_kps_rootsift.append(len(j))
```

In [ ]:

```python
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
_rootsift[j:j+2][::-1],points_all_left_rootsift[j:j+2][::-1],descriptors_all_left_rootsi
ft[j:j+2][::-1])
    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_rig
ht_rootsift[j:j+2][::-1],points_all_right_rootsift[j:j+2][::-1],descriptors_all_right_ro
otsift[j:j+2][::-1])
    H_right_rootsift.append(H_a)
    num_matches_rootsift.append(matches)
    num_good_matches_rootsift.append(gd_matches)
```

In [ ]:

```python
xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_rootsift,H_right_rootsift)
```

In [ ]:

```python
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_rootsift,xmax,x
min,ymax,ymin,t,h,w,Ht)
```

In [ ]:

```
warp_imgs_all_rootsift = final_step_right_union(warp_imgs_left,images_right_bgr_no_enhanc
e,H_right_rootsift,xmax,xmin,ymax,ymin,t,h,w,Ht)
```

In [ ]:

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

For BRISK 110 image

In [ ]:

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

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


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


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

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

```
100%|██████████| 51/51 [00:48<00:00,  1.06it/s]
100%|██████████| 59/59 [00:49<00:00,  1.20it/s]
```

In [ ]:

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

```
100%|██████████| 110/110 [00:00<00:00, 327912.89it/s]
```

In [ ]:

```
H_left_brisk = []
H_right_brisk = []

num_matches_brisk = []
num_good_matches_brisk = []

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

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_brisk[j:j+2][::-1],points_all_left_brisk[j:j+2][::-1],descriptors_all_left_brisk[j:j+2]
```

```
[::-1])
    H_left_brisk.append(H_a)
    num_matches_brisk.append(matches)
    num_good_matches_brisk.append(gd_matches)

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

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

  2%|▏ | 1/51 [00:02<02:22, 2.85s/it]

```
Number of matches 32653
Number of matches After Lowe's Ratio 2170
Number of Robust matches 1357
```

  4%|▍ | 2/51 [00:05<02:23, 2.94s/it]

```
Number of matches 32146
Number of matches After Lowe's Ratio 2338
Number of Robust matches 1561
```

  6%|▋ | 3/51 [00:09<02:25, 3.04s/it]

```
Number of matches 37734
Number of matches After Lowe's Ratio 2467
Number of Robust matches 1622
```

  8%|▊ | 4/51 [00:13<02:36, 3.33s/it]

```
Number of matches 37547
Number of matches After Lowe's Ratio 3491
Number of Robust matches 2593
```

 10%|█ | 5/51 [00:17<02:39, 3.46s/it]

```
Number of matches 34839
Number of matches After Lowe's Ratio 2751
Number of Robust matches 2054
```

 12%|█▏ | 6/51 [00:20<02:34, 3.42s/it]

```
Number of matches 30911
Number of matches After Lowe's Ratio 2663
Number of Robust matches 2050
```

 14%|█▍ | 7/51 [00:23<02:26, 3.32s/it]

```
Number of matches 32047
Number of matches After Lowe's Ratio 2557
Number of Robust matches 1907
```

 16%|█▌ | 8/51 [00:26<02:21, 3.30s/it]

```
Number of matches 33078
```

```
Number of matches After Lowe's Ratio 2974
Number of Robust matches 2181


  18%|██        | 9/51 [00:30<02:19,  3.32s/it]

Number of matches 31280
Number of matches After Lowe's Ratio 3160
Number of Robust matches 2459


  20%|██        | 10/51 [00:33<02:13,  3.25s/it]

Number of matches 31427
Number of matches After Lowe's Ratio 2378
Number of Robust matches 1731


  22%|██        | 11/51 [00:36<02:08,  3.20s/it]

Number of matches 32135
Number of matches After Lowe's Ratio 1942
Number of Robust matches 1129


  24%|██        | 12/51 [00:39<02:05,  3.22s/it]

Number of matches 31815
Number of matches After Lowe's Ratio 2119
Number of Robust matches 1332


  25%|██        | 13/51 [00:42<02:01,  3.19s/it]

Number of matches 33078
Number of matches After Lowe's Ratio 2309
Number of Robust matches 1307


  27%|██        | 14/51 [00:46<02:00,  3.25s/it]

Number of matches 35870
Number of matches After Lowe's Ratio 1915
Number of Robust matches 1176


  29%|██        | 15/51 [00:50<02:07,  3.54s/it]

Number of matches 43958
Number of matches After Lowe's Ratio 2227
Number of Robust matches 879


  31%|███       | 16/51 [00:55<02:19,  3.98s/it]

Number of matches 37987
Number of matches After Lowe's Ratio 1862
Number of Robust matches 861


  33%|███       | 17/51 [00:59<02:15,  3.99s/it]

Number of matches 32058
Number of matches After Lowe's Ratio 1766
Number of Robust matches 951
```

```
35%|███         | 18/51 [01:02<02:02,  3.72s/it]
```

Number of matches 30297
Number of matches After Lowe's Ratio 1548
Number of Robust matches 577

```
37%|███         | 19/51 [01:05<01:52,  3.52s/it]
```

Number of matches 33725
Number of matches After Lowe's Ratio 1002
Number of Robust matches 392

```
39%|███         | 20/51 [01:08<01:49,  3.53s/it]
```

Number of matches 34224
Number of matches After Lowe's Ratio 1413
Number of Robust matches 551

```
41%|████        | 21/51 [01:12<01:45,  3.50s/it]
```

Number of matches 34530
Number of matches After Lowe's Ratio 689
Number of Robust matches 246

```
43%|████        | 22/51 [01:15<01:39,  3.43s/it]
```

Number of matches 24599
Number of matches After Lowe's Ratio 389
Number of Robust matches 44

```
45%|████        | 23/51 [01:17<01:26,  3.09s/it]
```

Number of matches 24704
Number of matches After Lowe's Ratio 1398
Number of Robust matches 666

```
47%|█████       | 24/51 [01:20<01:15,  2.79s/it]
```

Number of matches 21196
Number of matches After Lowe's Ratio 1365
Number of Robust matches 681

```
49%|█████       | 25/51 [01:21<01:05,  2.54s/it]
```

Number of matches 26252
Number of matches After Lowe's Ratio 1327
Number of Robust matches 653

```
51%|█████       | 26/51 [01:24<01:03,  2.54s/it]
```

Number of matches 32005
Number of matches After Lowe's Ratio 1718
Number of Robust matches 752

```
53%|█████       | 27/51 [01:28<01:08,  2.86s/it]
```

Number of matches 44696

```
Number of matches After Lowe's Ratio 1773
Number of Robust matches 647


 55%|███████         | 28/51 [01:34<01:29,  3.91s/it]

Number of matches 48468
Number of matches After Lowe's Ratio 2358
Number of Robust matches 686


 57%|███████         | 29/51 [01:41<01:43,  4.69s/it]

Number of matches 44596
Number of matches After Lowe's Ratio 2135
Number of Robust matches 740


 59%|████████        | 30/51 [01:46<01:42,  4.89s/it]

Number of matches 35503
Number of matches After Lowe's Ratio 2129
Number of Robust matches 1063


 61%|████████        | 31/51 [01:50<01:30,  4.55s/it]

Number of matches 32924
Number of matches After Lowe's Ratio 2527
Number of Robust matches 1351


 63%|████████        | 32/51 [01:53<01:18,  4.13s/it]

Number of matches 30917
Number of matches After Lowe's Ratio 2557
Number of Robust matches 1738


 65%|█████████       | 33/51 [01:56<01:08,  3.78s/it]

Number of matches 30511
Number of matches After Lowe's Ratio 2757
Number of Robust matches 1782


 67%|█████████       | 34/51 [01:59<01:02,  3.66s/it]

Number of matches 36828
Number of matches After Lowe's Ratio 2533
Number of Robust matches 1471


 69%|█████████       | 35/51 [02:03<01:00,  3.80s/it]

Number of matches 39748
Number of matches After Lowe's Ratio 2999
Number of Robust matches 1708


 71%|██████████      | 36/51 [02:08<00:59,  3.99s/it]

Number of matches 38033
Number of matches After Lowe's Ratio 3085
Number of Robust matches 1605
```

```
 73%|██████      | 37/51 [02:12<00:57,  4.08s/it]

Number of matches 39826
Number of matches After Lowe's Ratio 3011
Number of Robust matches 1598


 75%|██████      | 38/51 [02:18<01:01,  4.74s/it]

Number of matches 33296
Number of matches After Lowe's Ratio 2040
Number of Robust matches 1265


 76%|███████     | 39/51 [02:22<00:52,  4.38s/it]

Number of matches 31758
Number of matches After Lowe's Ratio 3403
Number of Robust matches 2336


 78%|███████     | 40/51 [02:25<00:44,  4.04s/it]

Number of matches 31028
Number of matches After Lowe's Ratio 3026
Number of Robust matches 2146


 80%|███████     | 41/51 [02:28<00:36,  3.69s/it]

Number of matches 27881
Number of matches After Lowe's Ratio 1762
Number of Robust matches 1120


 82%|████████    | 42/51 [02:31<00:30,  3.37s/it]

Number of matches 27362
Number of matches After Lowe's Ratio 1664
Number of Robust matches 1048


 84%|████████    | 43/51 [02:33<00:24,  3.10s/it]

Number of matches 27680
Number of matches After Lowe's Ratio 2330
Number of Robust matches 1713


 86%|████████    | 44/51 [02:36<00:20,  2.97s/it]

Number of matches 32777
Number of matches After Lowe's Ratio 2206
Number of Robust matches 1174


 88%|████████    | 45/51 [02:39<00:18,  3.05s/it]

Number of matches 27042
Number of matches After Lowe's Ratio 2064
Number of Robust matches 1476


 90%|█████████   | 46/51 [02:41<00:14,  2.90s/it]

Number of matches 30160
```

Number of matches 29160
Number of matches After Lowe's Ratio 1890
Number of Robust matches 848

```
 92%|████████▊ | 47/51 [02:44<00:11,  2.88s/it]
```

Number of matches 32830
Number of matches After Lowe's Ratio 2771
Number of Robust matches 1328

```
 94%|█████████ | 48/51 [02:48<00:09,  3.11s/it]
```

Number of matches 33004
Number of matches After Lowe's Ratio 1826
Number of Robust matches 691

```
 96%|█████████▏| 49/51 [02:52<00:06,  3.30s/it]
```

Number of matches 35929
Number of matches After Lowe's Ratio 2738
Number of Robust matches 1059

```
  0%|          | 0/59 [00:00<?, ?it/s]
```

Number of matches 25316
Number of matches After Lowe's Ratio 839
Number of Robust matches 238

```
  2%|▏         | 1/59 [00:02<02:50,  2.94s/it]
```

Number of matches 22854
Number of matches After Lowe's Ratio 1641
Number of Robust matches 961

```
  3%|▎         | 2/59 [00:05<02:36,  2.74s/it]
```

Number of matches 32280
Number of matches After Lowe's Ratio 1298
Number of Robust matches 570

```
  5%|▌         | 3/59 [00:08<02:38,  2.83s/it]
```

Number of matches 26534
Number of matches After Lowe's Ratio 1956
Number of Robust matches 872

```
  7%|▋         | 4/59 [00:10<02:32,  2.78s/it]
```

Number of matches 28302
Number of matches After Lowe's Ratio 1863
Number of Robust matches 913

```
  8%|▊         | 5/59 [00:13<02:27,  2.73s/it]
```

Number of matches 23435
Number of matches After Lowe's Ratio 1757
Number of Robust matches 1046

```
 10%|█          | 6/59 [00:15<02:15,  2.55s/it]
```

Number of matches 26028
Number of matches After Lowe's Ratio 1633
Number of Robust matches 765

```
 12%|█          | 7/59 [00:18<02:13,  2.57s/it]
```

Number of matches 30921
Number of matches After Lowe's Ratio 534
Number of Robust matches 11

```
 14%|█          | 8/59 [00:21<02:15,  2.66s/it]
```

Number of matches 25059
Number of matches After Lowe's Ratio 712
Number of Robust matches 240

```
 15%|█          | 9/59 [00:23<02:05,  2.52s/it]
```

Number of matches 23035
Number of matches After Lowe's Ratio 722
Number of Robust matches 310

```
 17%|█          | 10/59 [00:25<01:55,  2.36s/it]
```

Number of matches 24778
Number of matches After Lowe's Ratio 904
Number of Robust matches 402

```
 19%|█          | 11/59 [00:28<01:57,  2.46s/it]
```

Number of matches 35128
Number of matches After Lowe's Ratio 1816
Number of Robust matches 1216

```
 20%|██         | 12/59 [00:31<02:08,  2.73s/it]
```

Number of matches 28715
Number of matches After Lowe's Ratio 2213
Number of Robust matches 1584

```
 22%|██         | 13/59 [00:33<02:03,  2.68s/it]
```

Number of matches 25864
Number of matches After Lowe's Ratio 1205
Number of Robust matches 739

```
 24%|██         | 14/59 [00:36<01:57,  2.60s/it]
```

Number of matches 24371
Number of matches After Lowe's Ratio 595
Number of Robust matches 253

```
 25%|██         | 15/59 [00:38<01:47,  2.44s/it]
```

```
Number of matches 21250
Number of matches After Lowe's Ratio 1599
Number of Robust matches 1084


 27%|██▌         | 16/59 [00:40<01:39,  2.32s/it]

Number of matches 31082
Number of matches After Lowe's Ratio 1103
Number of Robust matches 607


 29%|██▌         | 17/59 [00:43<01:46,  2.54s/it]

Number of matches 31880
Number of matches After Lowe's Ratio 2734
Number of Robust matches 1901


 31%|███         | 18/59 [00:47<01:56,  2.83s/it]

Number of matches 33259
Number of matches After Lowe's Ratio 2985
Number of Robust matches 2417


 32%|███         | 19/59 [00:50<01:59,  2.98s/it]

Number of matches 29687
Number of matches After Lowe's Ratio 2424
Number of Robust matches 2032


 34%|███▍        | 20/59 [00:53<02:00,  3.10s/it]

Number of matches 33001
Number of matches After Lowe's Ratio 2445
Number of Robust matches 1709


 36%|███▌        | 21/59 [00:57<02:02,  3.21s/it]

Number of matches 33071
Number of matches After Lowe's Ratio 1853
Number of Robust matches 1322


 37%|███▋        | 22/59 [01:00<02:02,  3.32s/it]

Number of matches 35123
Number of matches After Lowe's Ratio 2208
Number of Robust matches 1511


 39%|███▉        | 23/59 [01:04<02:05,  3.48s/it]

Number of matches 39155
Number of matches After Lowe's Ratio 2279
Number of Robust matches 1444


 41%|████        | 24/59 [01:08<02:09,  3.70s/it]

Number of matches 37668
Number of matches After Lowe's Ratio 2534
Number of Robust matches 1430
```

```
 42%|██        | 25/59 [01:13<02:17,  4.03s/it]
```

Number of matches 40615
Number of matches After Lowe's Ratio 2837
Number of Robust matches 1194

```
 44%|███       | 26/59 [01:17<02:15,  4.10s/it]
```

Number of matches 35723
Number of matches After Lowe's Ratio 2593
Number of Robust matches 1269

```
 46%|████      | 27/59 [01:21<02:05,  3.92s/it]
```

Number of matches 29133
Number of matches After Lowe's Ratio 1968
Number of Robust matches 908

```
 47%|████      | 28/59 [01:24<01:52,  3.62s/it]
```

Number of matches 31575
Number of matches After Lowe's Ratio 2590
Number of Robust matches 859

```
 49%|████      | 29/59 [01:27<01:45,  3.52s/it]
```

Number of matches 30053
Number of matches After Lowe's Ratio 2222
Number of Robust matches 712

```
 51%|█████     | 30/59 [01:30<01:35,  3.28s/it]
```

Number of matches 24008
Number of matches After Lowe's Ratio 1563
Number of Robust matches 686

```
 53%|█████     | 31/59 [01:32<01:23,  2.99s/it]
```

Number of matches 29051
Number of matches After Lowe's Ratio 1383
Number of Robust matches 642

```
 54%|█████     | 32/59 [01:35<01:22,  3.07s/it]
```

Number of matches 45494
Number of matches After Lowe's Ratio 578
Number of Robust matches 111

```
 56%|█████     | 33/59 [01:41<01:41,  3.92s/it]
```

Number of matches 41453
Number of matches After Lowe's Ratio 1103
Number of Robust matches 372

```
 58%|█████     | 34/59 [01:47<01:51,  4.47s/it]
```

```
Number of matches 47391
Number of matches After Lowe's Ratio 362
Number of Robust matches 5


 59%|██████▏      | 35/59 [01:53<01:55,  4.82s/it]

Number of matches 36711
Number of matches After Lowe's Ratio 1005
Number of Robust matches 319


 61%|██████▍      | 36/59 [01:57<01:44,  4.54s/it]

Number of matches 34496
Number of matches After Lowe's Ratio 1884
Number of Robust matches 779


 63%|██████▌      | 37/59 [02:00<01:32,  4.19s/it]

Number of matches 32321
Number of matches After Lowe's Ratio 2032
Number of Robust matches 680


 64%|██████▊      | 38/59 [02:03<01:20,  3.83s/it]

Number of matches 28452
Number of matches After Lowe's Ratio 1635
Number of Robust matches 530


 66%|██████▉      | 39/59 [02:06<01:09,  3.48s/it]

Number of matches 26073
Number of matches After Lowe's Ratio 1390
Number of Robust matches 439


 68%|███████      | 40/59 [02:08<00:59,  3.13s/it]

Number of matches 27594
Number of matches After Lowe's Ratio 1356
Number of Robust matches 428


 69%|███████▏     | 41/59 [02:11<00:54,  3.01s/it]

Number of matches 29922
Number of matches After Lowe's Ratio 2392
Number of Robust matches 780


 71%|███████▍     | 42/59 [02:14<00:51,  3.02s/it]

Number of matches 31761
Number of matches After Lowe's Ratio 1460
Number of Robust matches 404


 73%|███████▌     | 43/59 [02:17<00:48,  3.03s/it]

Number of matches 28598
Number of matches After Lowe's Ratio 2069
Number of Robust matches 900
```

```
 75%|███████    | 44/59 [02:20<00:44,  2.96s/it]

Number of matches 32677
Number of matches After Lowe's Ratio 1941
Number of Robust matches 688


 76%|███████    | 45/59 [02:23<00:43,  3.08s/it]

Number of matches 25600
Number of matches After Lowe's Ratio 1482
Number of Robust matches 626


 78%|███████    | 46/59 [02:25<00:37,  2.87s/it]

Number of matches 28462
Number of matches After Lowe's Ratio 1087
Number of Robust matches 753


 80%|████████   | 47/59 [02:28<00:33,  2.83s/it]

Number of matches 28784
Number of matches After Lowe's Ratio 1396
Number of Robust matches 967


 81%|████████   | 48/59 [02:31<00:31,  2.84s/it]

Number of matches 27866
Number of matches After Lowe's Ratio 1431
Number of Robust matches 956


 83%|████████   | 49/59 [02:33<00:27,  2.76s/it]

Number of matches 25725
Number of matches After Lowe's Ratio 2258
Number of Robust matches 1588


 85%|████████   | 50/59 [02:36<00:23,  2.62s/it]

Number of matches 25632
Number of matches After Lowe's Ratio 1239
Number of Robust matches 697


 86%|████████   | 51/59 [02:38<00:20,  2.53s/it]

Number of matches 25983
Number of matches After Lowe's Ratio 2242
Number of Robust matches 1450


 88%|████████   | 52/59 [02:40<00:16,  2.38s/it]

Number of matches 13694
Number of matches After Lowe's Ratio 736
Number of Robust matches 422


 90%|█████████  | 53/59 [02:41<00:11,  1.97s/it]
```

```
Number of matches 9250
Number of matches After Lowe's Ratio 1004
Number of Robust matches 578
```

```
 92%|██████████        | 54/59 [02:42<00:07,  1.58s/it]
```

```
Number of matches 10843
Number of matches After Lowe's Ratio 598
Number of Robust matches 357
```

```
 93%|██████████        | 55/59 [02:43<00:05,  1.33s/it]
```

```
Number of matches 12481
Number of matches After Lowe's Ratio 1368
Number of Robust matches 889
```

```
 95%|██████████        | 56/59 [02:44<00:03,  1.23s/it]
```

```
Number of matches 22262
Number of matches After Lowe's Ratio 1268
Number of Robust matches 760
```

```
 97%|██████████        | 57/59 [02:46<00:02,  1.47s/it]
```

```
Number of matches 25793
Number of matches After Lowe's Ratio 1895
Number of Robust matches 1288
```

```
 98%|██████████        | 58/59 [02:48<00:01,  1.79s/it]
```

```
Number of matches 25355
Number of matches After Lowe's Ratio 2014
Number of Robust matches 1211
```

In [ ]:

```python
xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_brisk,H_right_brisk)
```

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

In [ ]:

```python
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_brisk,xmax,xmin
,ymax,ymin,t,h,w,Ht)
```

In [ ]:

```python
warp_imgs_all_brisk = final_step_right_union(warp_imgs_left,images_right_bgr_no_enhance,H
_right_brisk,xmax,xmin,ymax,ymin,t,h,w,Ht)
```

In [ ]:

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

For Surf 110 images

In [ ]:

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

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

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

```
100%|██████████| 51/51 [06:45<00:00,  7.96s/it]
100%|██████████| 59/59 [07:35<00:00,  7.72s/it]
```

In [ ]:

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

```
100%|██████████| 110/110 [00:00<00:00, 220015.95it/s]
```

In [ ]:

```python
H_left_surf = []
H_right_surf = []

num_matches_surf = []
num_good_matches_surf = []

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

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

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

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

```
  2%|          | 1/51 [00:03<02:51,  3.42s/it]
```

```
Number of matches 34564
Number of matches After Lowe's Ratio 4305
Number of Robust matches 2365
```

```
  4%|█          | 2/51 [00:06<02:47,  3.42s/it]
```

```
Number of matches 34700
Number of matches After Lowe's Ratio 3942
Number of Robust matches 2105
```

```
  6%|█          | 3/51 [00:10<02:51,  3.58s/it]
```

```
Number of matches 37406
Number of matches After Lowe's Ratio 4528
Number of Robust matches 2272
```

```
  8%|█          | 4/51 [00:14<02:53,  3.69s/it]
```

```
Number of matches 38907
Number of matches After Lowe's Ratio 6807
Number of Robust matches 4559
```

```
 10%|█          | 5/51 [00:18<02:56,  3.85s/it]
```

```
Number of matches 37650
Number of matches After Lowe's Ratio 6076
Number of Robust matches 3714
```

```
 12%|█          | 6/51 [00:22<02:54,  3.87s/it]
```

```
Number of matches 38049
Number of matches After Lowe's Ratio 5952
Number of Robust matches 3824
```

```
 14%|█          | 7/51 [00:27<02:54,  3.95s/it]
```

```
Number of matches 38270
Number of matches After Lowe's Ratio 6071
Number of Robust matches 4053
```

```
 16%|██         | 8/51 [00:31<02:51,  3.98s/it]
```

```
Number of matches 38222
Number of matches After Lowe's Ratio 6868
Number of Robust matches 4666
```

```
 18%|██         | 9/51 [00:35<02:49,  4.03s/it]
```

```
Number of matches 37766
Number of matches After Lowe's Ratio 7482
Number of Robust matches 5123
```

```
 20%|██         | 10/51 [00:39<02:44,  4.01s/it]
```

```
Number of matches 38678
Number of matches After Lowe's Ratio 6077
Number of Robust matches 3810
```

```
 22%|██         | 11/51 [00:43<02:41,  4.05s/it]
```

```
Number of matches 38137
Number of matches After Lowe's Ratio 4761
Number of Robust matches 2887


 24%|██         | 12/51 [00:47<02:35,  3.98s/it]

Number of matches 37525
Number of matches After Lowe's Ratio 5494
Number of Robust matches 3266


 25%|██         | 13/51 [00:51<02:30,  3.96s/it]

Number of matches 37759
Number of matches After Lowe's Ratio 4505
Number of Robust matches 2426


 27%|██         | 14/51 [00:55<02:26,  3.96s/it]

Number of matches 38066
Number of matches After Lowe's Ratio 4905
Number of Robust matches 2895


 29%|██         | 15/51 [00:59<02:24,  4.02s/it]

Number of matches 38808
Number of matches After Lowe's Ratio 2611
Number of Robust matches 970


 31%|███        | 16/51 [01:03<02:19,  4.00s/it]

Number of matches 37519
Number of matches After Lowe's Ratio 3045
Number of Robust matches 1237


 33%|███        | 17/51 [01:06<02:13,  3.92s/it]

Number of matches 35706
Number of matches After Lowe's Ratio 3938
Number of Robust matches 1816


 35%|███        | 18/51 [01:10<02:10,  3.96s/it]

Number of matches 39467
Number of matches After Lowe's Ratio 3282
Number of Robust matches 1162


 37%|███        | 19/51 [01:14<02:07,  3.98s/it]

Number of matches 36038
Number of matches After Lowe's Ratio 2088
Number of Robust matches 694


 39%|████       | 20/51 [01:18<02:02,  3.95s/it]

Number of matches 37306
Number of matches After Lowe's Ratio 3300
Number of Robust matches 1358
```

```
 41%|████       | 21/51 [01:22<01:58,  3.93s/it]
```

Number of matches 35977
Number of matches After Lowe's Ratio 1965
Number of Robust matches 661

```
 43%|████       | 22/51 [01:26<01:51,  3.86s/it]
```

Number of matches 35736
Number of matches After Lowe's Ratio 1506
Number of Robust matches 256

```
 45%|████       | 23/51 [01:30<01:47,  3.83s/it]
```

Number of matches 36312
Number of matches After Lowe's Ratio 4398
Number of Robust matches 2430

```
 47%|████       | 24/51 [01:33<01:42,  3.78s/it]
```

Number of matches 35698
Number of matches After Lowe's Ratio 4733
Number of Robust matches 2775

```
 49%|████       | 25/51 [01:37<01:38,  3.78s/it]
```

Number of matches 36283
Number of matches After Lowe's Ratio 4363
Number of Robust matches 2524

```
 51%|█████      | 26/51 [01:41<01:34,  3.78s/it]
```

Number of matches 37204
Number of matches After Lowe's Ratio 4886
Number of Robust matches 2603

```
 53%|█████      | 27/51 [01:45<01:34,  3.92s/it]
```

Number of matches 38737
Number of matches After Lowe's Ratio 4205
Number of Robust matches 2002

```
 55%|█████      | 28/51 [01:49<01:32,  4.00s/it]
```

Number of matches 40144
Number of matches After Lowe's Ratio 4512
Number of Robust matches 1567

```
 57%|█████      | 29/51 [01:54<01:30,  4.12s/it]
```

Number of matches 39400
Number of matches After Lowe's Ratio 4116
Number of Robust matches 1725

```
 59%|█████      | 30/51 [01:58<01:27,  4.15s/it]
```

```
 59%|██████     | 30/51 [01:58<01:27,  4.15s/it]
```

Number of matches 38368
Number of matches After Lowe's Ratio 5089
Number of Robust matches 2513

```
 61%|██████     | 31/51 [02:02<01:23,  4.18s/it]
```

Number of matches 38791
Number of matches After Lowe's Ratio 5948
Number of Robust matches 2992

```
 63%|███████    | 32/51 [02:06<01:18,  4.15s/it]
```

Number of matches 38100
Number of matches After Lowe's Ratio 6010
Number of Robust matches 3725

```
 65%|███████    | 33/51 [02:10<01:14,  4.15s/it]
```

Number of matches 39195
Number of matches After Lowe's Ratio 6882
Number of Robust matches 4280

```
 67%|███████    | 34/51 [02:15<01:10,  4.16s/it]
```

Number of matches 40180
Number of matches After Lowe's Ratio 6296
Number of Robust matches 3925

```
 69%|███████    | 35/51 [02:19<01:07,  4.21s/it]
```

Number of matches 40454
Number of matches After Lowe's Ratio 6637
Number of Robust matches 3764

```
 71%|███████    | 36/51 [02:23<01:03,  4.20s/it]
```

Number of matches 39823
Number of matches After Lowe's Ratio 6867
Number of Robust matches 4144

```
 73%|████████   | 37/51 [02:27<00:59,  4.23s/it]
```

Number of matches 39851
Number of matches After Lowe's Ratio 6522
Number of Robust matches 4005

```
 75%|████████   | 38/51 [02:31<00:54,  4.16s/it]
```

Number of matches 37448
Number of matches After Lowe's Ratio 4818
Number of Robust matches 2622

```
 76%|████████   | 39/51 [02:35<00:48,  4.07s/it]
```

Number of matches 36805
Number of matches After Lowe's Ratio 8235

```
Number of Robust matches 5143


 78%|████████   | 40/51 [02:39<00:44,  4.04s/it]

Number of matches 39522
Number of matches After Lowe's Ratio 7844
Number of Robust matches 5155


 80%|████████   | 41/51 [02:43<00:40,  4.08s/it]

Number of matches 38125
Number of matches After Lowe's Ratio 5500
Number of Robust matches 2727


 82%|████████   | 42/51 [02:47<00:36,  4.01s/it]

Number of matches 37529
Number of matches After Lowe's Ratio 5607
Number of Robust matches 3291


 84%|████████   | 43/51 [02:51<00:32,  4.03s/it]

Number of matches 38691
Number of matches After Lowe's Ratio 6988
Number of Robust matches 4096


 86%|████████   | 44/51 [02:55<00:27,  4.00s/it]

Number of matches 35997
Number of matches After Lowe's Ratio 4511
Number of Robust matches 2263


 88%|████████   | 45/51 [02:59<00:23,  3.95s/it]

Number of matches 35242
Number of matches After Lowe's Ratio 4515
Number of Robust matches 2359


 90%|████████   | 46/51 [03:03<00:19,  3.84s/it]

Number of matches 36041
Number of matches After Lowe's Ratio 4754
Number of Robust matches 2309


 92%|████████   | 47/51 [03:07<00:15,  3.84s/it]

Number of matches 37450
Number of matches After Lowe's Ratio 5994
Number of Robust matches 2647


 94%|████████   | 48/51 [03:11<00:11,  3.89s/it]

Number of matches 38454
Number of matches After Lowe's Ratio 3737
Number of Robust matches 1405
```

```
  96%|████████| | 49/51 [03:15<00:07,  3.98s/it]
```

Number of matches 38388
Number of matches After Lowe's Ratio 5342
Number of Robust matches 2143

```
   0%|          | 0/59 [00:00<?, ?it/s]
```

Number of matches 38521
Number of matches After Lowe's Ratio 2315
Number of Robust matches 558

```
   2%|          | 1/59 [00:03<03:47,  3.93s/it]
```

Number of matches 36010
Number of matches After Lowe's Ratio 3959
Number of Robust matches 1974

```
   3%|          | 2/59 [00:08<03:47,  3.99s/it]
```

Number of matches 39467
Number of matches After Lowe's Ratio 3437
Number of Robust matches 1536

```
   5%|          | 3/59 [00:12<03:46,  4.05s/it]
```

Number of matches 38139
Number of matches After Lowe's Ratio 4059
Number of Robust matches 2122

```
   7%|          | 4/59 [00:16<03:46,  4.13s/it]
```

Number of matches 39256
Number of matches After Lowe's Ratio 4416
Number of Robust matches 1974

```
   8%|          | 5/59 [00:20<03:46,  4.20s/it]
```

Number of matches 42974
Number of matches After Lowe's Ratio 4294
Number of Robust matches 1917

```
  10%|          | 6/59 [00:25<03:48,  4.31s/it]
```

Number of matches 39642
Number of matches After Lowe's Ratio 5068
Number of Robust matches 2280

```
  12%|          | 7/59 [00:29<03:44,  4.33s/it]
```

Number of matches 41128
Number of matches After Lowe's Ratio 1279
Number of Robust matches 62

```
  14%|          | 8/59 [00:34<03:42,  4.37s/it]
```

Number of matches 41423
Number of matches After Lowe's Ratio 2256

```
Number of Robust matches 578


 15%|█             | 9/59 [00:38<03:39,  4.39s/it]

Number of matches 42807
Number of matches After Lowe's Ratio 3007
Number of Robust matches 1217


 17%|█             | 10/59 [00:43<03:38,  4.45s/it]

Number of matches 39765
Number of matches After Lowe's Ratio 3521
Number of Robust matches 1642


 19%|█             | 11/59 [00:47<03:30,  4.38s/it]

Number of matches 40727
Number of matches After Lowe's Ratio 4898
Number of Robust matches 3072


 20%|█             | 12/59 [00:51<03:23,  4.32s/it]

Number of matches 35726
Number of matches After Lowe's Ratio 5002
Number of Robust matches 2687


 22%|█             | 13/59 [00:55<03:05,  4.03s/it]

Number of matches 29685
Number of matches After Lowe's Ratio 2599
Number of Robust matches 1080


 24%|█             | 14/59 [00:58<02:46,  3.71s/it]

Number of matches 32721
Number of matches After Lowe's Ratio 2058
Number of Robust matches 785


 25%|██            | 15/59 [01:01<02:37,  3.59s/it]

Number of matches 29698
Number of matches After Lowe's Ratio 4404
Number of Robust matches 2883


 27%|██            | 16/59 [01:04<02:28,  3.45s/it]

Number of matches 39479
Number of matches After Lowe's Ratio 3663
Number of Robust matches 1751


 29%|██            | 17/59 [01:08<02:33,  3.66s/it]

Number of matches 37048
Number of matches After Lowe's Ratio 6342
Number of Robust matches 3696
```

```
 31%|███        | 18/59 [01:12<02:34,  3.76s/it]
```

Number of matches 39520
Number of matches After Lowe's Ratio 7069
Number of Robust matches 5244

```
 32%|███        | 19/59 [01:16<02:35,  3.88s/it]
```

Number of matches 36055
Number of matches After Lowe's Ratio 5823
Number of Robust matches 3951

```
 34%|███        | 20/59 [01:20<02:29,  3.84s/it]
```

Number of matches 36244
Number of matches After Lowe's Ratio 6158
Number of Robust matches 4584

```
 36%|████       | 21/59 [01:24<02:25,  3.83s/it]
```

Number of matches 35202
Number of matches After Lowe's Ratio 4064
Number of Robust matches 2576

```
 37%|████       | 22/59 [01:28<02:20,  3.80s/it]
```

Number of matches 37479
Number of matches After Lowe's Ratio 4890
Number of Robust matches 3416

```
 39%|████       | 23/59 [01:32<02:18,  3.86s/it]
```

Number of matches 36769
Number of matches After Lowe's Ratio 4567
Number of Robust matches 2282

```
 41%|████       | 24/59 [01:35<02:14,  3.84s/it]
```

Number of matches 37985
Number of matches After Lowe's Ratio 4618
Number of Robust matches 2230

```
 42%|█████      | 25/59 [01:39<02:11,  3.87s/it]
```

Number of matches 36813
Number of matches After Lowe's Ratio 4421
Number of Robust matches 1926

```
 44%|█████      | 26/59 [01:43<02:09,  3.91s/it]
```

Number of matches 37749
Number of matches After Lowe's Ratio 5481
Number of Robust matches 2884

```
 46%|█████      | 27/59 [01:48<02:07,  3.99s/it]
```

Number of matches 39377
Number of matches After Lowe's Ratio 5147

```
Number of matches After Lowe's Ratio 5147
Number of Robust matches 2125


 47%|█████        | 28/59 [01:52<02:07,  4.11s/it]

Number of matches 38479
Number of matches After Lowe's Ratio 6090
Number of Robust matches 2625


 49%|█████        | 29/59 [01:56<02:02,  4.07s/it]

Number of matches 35539
Number of matches After Lowe's Ratio 5383
Number of Robust matches 2066


 51%|█████        | 30/59 [02:00<01:56,  4.02s/it]

Number of matches 37695
Number of matches After Lowe's Ratio 4506
Number of Robust matches 1609


 53%|█████        | 31/59 [02:04<01:51,  3.98s/it]

Number of matches 36113
Number of matches After Lowe's Ratio 3576
Number of Robust matches 1523


 54%|██████       | 32/59 [02:08<01:50,  4.09s/it]

Number of matches 40129
Number of matches After Lowe's Ratio 1612
Number of Robust matches 405


 56%|██████       | 33/59 [02:12<01:48,  4.18s/it]

Number of matches 40100
Number of matches After Lowe's Ratio 2465
Number of Robust matches 859


 58%|██████       | 34/59 [02:17<01:48,  4.32s/it]

Number of matches 40735
Number of matches After Lowe's Ratio 855
Number of Robust matches 9


 59%|██████       | 35/59 [02:21<01:44,  4.34s/it]

Number of matches 38881
Number of matches After Lowe's Ratio 2720
Number of Robust matches 857


 61%|██████       | 36/59 [02:26<01:37,  4.25s/it]

Number of matches 37388
Number of matches After Lowe's Ratio 3947
Number of Robust matches 1562
```

```
 63%|███████      | 37/59 [02:29<01:31,  4.15s/it]
```

Number of matches 35528
Number of matches After Lowe's Ratio 4457
Number of Robust matches 1575

```
 64%|███████      | 38/59 [02:33<01:24,  4.00s/it]
```

Number of matches 36593
Number of matches After Lowe's Ratio 3640
Number of Robust matches 1259

```
 66%|████████     | 39/59 [02:37<01:20,  4.00s/it]
```

Number of matches 40004
Number of matches After Lowe's Ratio 4587
Number of Robust matches 1357

```
 68%|████████     | 40/59 [02:41<01:17,  4.07s/it]
```

Number of matches 40698
Number of matches After Lowe's Ratio 4721
Number of Robust matches 1440

```
 69%|████████     | 41/59 [02:46<01:14,  4.15s/it]
```

Number of matches 40326
Number of matches After Lowe's Ratio 7525
Number of Robust matches 2756

```
 71%|████████     | 42/59 [02:50<01:10,  4.15s/it]
```

Number of matches 37769
Number of matches After Lowe's Ratio 4043
Number of Robust matches 1614

```
 73%|████████     | 43/59 [02:54<01:05,  4.08s/it]
```

Number of matches 34826
Number of matches After Lowe's Ratio 4041
Number of Robust matches 1933

```
 75%|████████     | 44/59 [02:57<00:58,  3.93s/it]
```

Number of matches 35065
Number of matches After Lowe's Ratio 4303
Number of Robust matches 1897

```
 76%|████████     | 45/59 [03:01<00:54,  3.87s/it]
```

Number of matches 34274
Number of matches After Lowe's Ratio 3927
Number of Robust matches 1962

```
 78%|████████     | 46/59 [03:05<00:49,  3.77s/it]
```

Number of matches 35716

```
Number of matches After Lowe's Ratio 3129
Number of Robust matches 1885


 80%|████████    | 47/59 [03:08<00:45,  3.75s/it]

Number of matches 36468
Number of matches After Lowe's Ratio 4042
Number of Robust matches 2504


 81%|████████    | 48/59 [03:12<00:41,  3.76s/it]

Number of matches 34147
Number of matches After Lowe's Ratio 3397
Number of Robust matches 1820


 83%|████████    | 49/59 [03:15<00:36,  3.65s/it]

Number of matches 32145
Number of matches After Lowe's Ratio 5679
Number of Robust matches 3859


 85%|████████    | 50/59 [03:19<00:32,  3.57s/it]

Number of matches 34742
Number of matches After Lowe's Ratio 4042
Number of Robust matches 1888


 86%|████████    | 51/59 [03:22<00:28,  3.57s/it]

Number of matches 34107
Number of matches After Lowe's Ratio 6333
Number of Robust matches 4054


 88%|████████    | 52/59 [03:26<00:24,  3.46s/it]

Number of matches 26532
Number of matches After Lowe's Ratio 2803
Number of Robust matches 1528


 90%|█████████   | 53/59 [03:28<00:19,  3.20s/it]

Number of matches 23023
Number of matches After Lowe's Ratio 3900
Number of Robust matches 1829


 92%|█████████   | 54/59 [03:30<00:14,  2.87s/it]

Number of matches 22981
Number of matches After Lowe's Ratio 2739
Number of Robust matches 1043


 93%|█████████   | 55/59 [03:32<00:10,  2.64s/it]

Number of matches 24402
Number of matches After Lowe's Ratio 4658
Number of Robust matches 2298
```

```
Number of matches 31323
Number of matches After Lowe's Ratio 3404
Number of Robust matches 1827
```

```
Number of matches 34496
Number of matches After Lowe's Ratio 5393
Number of Robust matches 3464
```

```
Number of matches 35721
Number of matches After Lowe's Ratio 5165
Number of Robust matches 2573
```

In [ ]:

```python
xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_surf,H_right_surf)
```

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

In [ ]:

```python
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_surf,xmax,xmin,
ymax,ymin,t,h,w,Ht)
```

In [ ]:

```python
warp_imgs_all_surf = final_step_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_
right_surf,xmax,xmin,ymax,ymin,t,h,w,Ht)
```

In [ ]:

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

In [ ]:

For Daisy 110 Images

In [41]:

```python
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 [01:09<00:00,  1.36s/it]
100%|████████| 59/59 [01:19<00:00,  1.35s/it]
```

In [42]:

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

```
100%|████████| 110/110 [00:00<00:00, 515501.05it/s]
```

In [43]:

```
H_left_daisy = []
H_right_daisy = []

num_matches_daisy = []
num_good_matches_daisy = []

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

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

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

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

```
  2%|         | 1/51 [00:02<01:52,  2.25s/it]
```

```
Number of matches 17448
Number of matches After Lowe's Ratio 2371
Number of Robust matches 1492
```

```
  4%|▊        | 2/51 [00:05<02:06,  2.59s/it]
```

```
Number of matches 15221
Number of matches After Lowe's Ratio 1388
Number of Robust matches 851
```

```
  6%|▊        | 3/51 [00:08<02:08,  2.69s/it]
```

```
Number of matches 19009
Number of matches After Lowe's Ratio 2318
```

```
Number of Robust matches 1561


  8%|█          | 4/51 [00:12<02:22,  3.03s/it]

Number of matches 18724
Number of matches After Lowe's Ratio 3989
Number of Robust matches 2650


 10%|█          | 5/51 [00:16<02:30,  3.26s/it]

Number of matches 18161
Number of matches After Lowe's Ratio 3105
Number of Robust matches 1963


 12%|█          | 6/51 [00:19<02:31,  3.37s/it]

Number of matches 17507
Number of matches After Lowe's Ratio 3106
Number of Robust matches 2194


 14%|█          | 7/51 [00:23<02:32,  3.47s/it]

Number of matches 16984
Number of matches After Lowe's Ratio 2773
Number of Robust matches 1862


 16%|██         | 8/51 [00:26<02:27,  3.43s/it]

Number of matches 16971
Number of matches After Lowe's Ratio 4021
Number of Robust matches 2766


 18%|██         | 9/51 [00:30<02:23,  3.42s/it]

Number of matches 17121
Number of matches After Lowe's Ratio 4269
Number of Robust matches 2625


 20%|██         | 10/51 [00:33<02:21,  3.46s/it]

Number of matches 17331
Number of matches After Lowe's Ratio 3431
Number of Robust matches 2201


 22%|██         | 11/51 [00:37<02:20,  3.50s/it]

Number of matches 19219
Number of matches After Lowe's Ratio 2611
Number of Robust matches 1295


 24%|██         | 12/51 [00:41<02:23,  3.67s/it]

Number of matches 18480
Number of matches After Lowe's Ratio 3531
Number of Robust matches 1820
```

```
 25%|██          | 13/51 [00:45<02:21,  3.72s/it]

Number of matches 19423
Number of matches After Lowe's Ratio 3185
Number of Robust matches 1793


 27%|██          | 14/51 [00:49<02:21,  3.82s/it]

Number of matches 19540
Number of matches After Lowe's Ratio 2972
Number of Robust matches 1834


 29%|██          | 15/51 [00:53<02:20,  3.91s/it]

Number of matches 23070
Number of matches After Lowe's Ratio 546
Number of Robust matches 170


 31%|███         | 16/51 [00:58<02:25,  4.17s/it]

Number of matches 19327
Number of matches After Lowe's Ratio 1075
Number of Robust matches 561


 33%|███         | 17/51 [01:02<02:20,  4.12s/it]

Number of matches 21616
Number of matches After Lowe's Ratio 2424
Number of Robust matches 1230


 35%|███         | 18/51 [01:06<02:19,  4.22s/it]

Number of matches 19935
Number of matches After Lowe's Ratio 1339
Number of Robust matches 529


 37%|███         | 19/51 [01:10<02:15,  4.24s/it]

Number of matches 22791
Number of matches After Lowe's Ratio 719
Number of Robust matches 300


 39%|███         | 20/51 [01:15<02:17,  4.44s/it]

Number of matches 21497
Number of matches After Lowe's Ratio 2548
Number of Robust matches 1135


 41%|████        | 21/51 [01:20<02:15,  4.52s/it]

Number of matches 20351
Number of matches After Lowe's Ratio 973
Number of Robust matches 325


 43%|████        | 22/51 [01:24<02:09,  4.46s/it]

Number of matches 17412
Number of matches After Lowe's Ratio 256
```

```
Number of Robust matches 25
```

 45%|██████ | 23/51 [01:28<01:57, 4.20s/it]

```
Number of matches 16896
Number of matches After Lowe's Ratio 2436
Number of Robust matches 1130
```

 47%|███████ | 24/51 [01:31<01:47, 3.97s/it]

```
Number of matches 16303
Number of matches After Lowe's Ratio 3008
Number of Robust matches 1708
```

 49%|████████ | 25/51 [01:35<01:37, 3.77s/it]

```
Number of matches 18249
Number of matches After Lowe's Ratio 2482
Number of Robust matches 1224
```

 51%|█████████ | 26/51 [01:39<01:36, 3.84s/it]

```
Number of matches 21853
Number of matches After Lowe's Ratio 3560
Number of Robust matches 1709
```

 53%|██████████ | 27/51 [01:43<01:38, 4.12s/it]

```
Number of matches 24851
Number of matches After Lowe's Ratio 3068
Number of Robust matches 1293
```

 55%|███████████ | 28/51 [01:49<01:44, 4.56s/it]

```
Number of matches 28347
Number of matches After Lowe's Ratio 3889
Number of Robust matches 1425
```

 57%|████████████ | 29/51 [01:55<01:51, 5.09s/it]

```
Number of matches 24822
Number of matches After Lowe's Ratio 3278
Number of Robust matches 1163
```

 59%|█████████████ | 30/51 [02:01<01:47, 5.13s/it]

```
Number of matches 20000
Number of matches After Lowe's Ratio 3199
Number of Robust matches 1752
```

 61%|██████████████ | 31/51 [02:05<01:36, 4.81s/it]

```
Number of matches 18074
Number of matches After Lowe's Ratio 3643
Number of Robust matches 2120
```

```
 63%|███████      | 32/51 [02:08<01:24,  4.44s/it]
```

Number of matches 16132
Number of matches After Lowe's Ratio 3441
Number of Robust matches 1893

```
 65%|███████      | 33/51 [02:11<01:13,  4.06s/it]
```

Number of matches 16505
Number of matches After Lowe's Ratio 4355
Number of Robust matches 3044

```
 67%|███████      | 34/51 [02:15<01:05,  3.86s/it]
```

Number of matches 17795
Number of matches After Lowe's Ratio 3637
Number of Robust matches 2087

```
 69%|███████      | 35/51 [02:18<01:00,  3.77s/it]
```

Number of matches 19052
Number of matches After Lowe's Ratio 4075
Number of Robust matches 2161

```
 71%|███████      | 36/51 [02:22<00:57,  3.81s/it]
```

Number of matches 18726
Number of matches After Lowe's Ratio 4917
Number of Robust matches 2735

```
 73%|████████     | 37/51 [02:26<00:53,  3.80s/it]
```

Number of matches 18580
Number of matches After Lowe's Ratio 4357
Number of Robust matches 2357

```
 75%|████████     | 38/51 [02:30<00:49,  3.78s/it]
```

Number of matches 15741
Number of matches After Lowe's Ratio 2448
Number of Robust matches 1541

```
 76%|████████     | 39/51 [02:33<00:42,  3.50s/it]
```

Number of matches 14586
Number of matches After Lowe's Ratio 4256
Number of Robust matches 3020

```
 78%|████████     | 40/51 [02:35<00:36,  3.28s/it]
```

Number of matches 16381
Number of matches After Lowe's Ratio 3990
Number of Robust matches 2674

```
 80%|████████     | 41/51 [02:38<00:31,  3.20s/it]
```

Number of matches 15190
Number of matches After Lowe's Ratio 3526

```
Number of matches After Lowe's Ratio 2526
Number of Robust matches 1711


 82%|████████   | 42/51 [02:41<00:27,  3.10s/it]

Number of matches 16204
Number of matches After Lowe's Ratio 2938
Number of Robust matches 2069


 84%|████████   | 43/51 [02:45<00:25,  3.13s/it]

Number of matches 16360
Number of matches After Lowe's Ratio 4007
Number of Robust matches 2919


 86%|████████   | 44/51 [02:48<00:21,  3.10s/it]

Number of matches 16749
Number of matches After Lowe's Ratio 2540
Number of Robust matches 1395


 88%|████████   | 45/51 [02:51<00:19,  3.18s/it]

Number of matches 16958
Number of matches After Lowe's Ratio 2942
Number of Robust matches 2003


 90%|████████   | 46/51 [02:54<00:16,  3.26s/it]

Number of matches 16883
Number of matches After Lowe's Ratio 2463
Number of Robust matches 1247


 92%|████████   | 47/51 [02:58<00:13,  3.30s/it]

Number of matches 16697
Number of matches After Lowe's Ratio 4045
Number of Robust matches 2188


 94%|████████   | 48/51 [03:01<00:10,  3.34s/it]

Number of matches 17245
Number of matches After Lowe's Ratio 1898
Number of Robust matches 768


 96%|████████   | 49/51 [03:05<00:06,  3.36s/it]

Number of matches 16937
Number of matches After Lowe's Ratio 3142
Number of Robust matches 1304


  0%|           | 0/59 [00:00<?, ?it/s]

Number of matches 14790
Number of matches After Lowe's Ratio 797
Number of Robust matches 234
```

```
  2%|▏        | 1/59 [00:03<03:32,  3.66s/it]
```

Number of matches 12557
Number of matches After Lowe's Ratio 1784
Number of Robust matches 1128

```
  3%|▎        | 2/59 [00:06<03:09,  3.32s/it]
```

Number of matches 19250
Number of matches After Lowe's Ratio 1219
Number of Robust matches 535

```
  5%|▍        | 3/59 [00:10<03:17,  3.53s/it]
```

Number of matches 17727
Number of matches After Lowe's Ratio 2586
Number of Robust matches 1341

```
  7%|▋        | 4/59 [00:13<03:18,  3.61s/it]
```

Number of matches 17667
Number of matches After Lowe's Ratio 2526
Number of Robust matches 1190

```
  8%|▊        | 5/59 [00:17<03:13,  3.58s/it]
```

Number of matches 16828
Number of matches After Lowe's Ratio 2299
Number of Robust matches 1362

```
 10%|█        | 6/59 [00:20<03:08,  3.55s/it]
```

Number of matches 16891
Number of matches After Lowe's Ratio 2664
Number of Robust matches 1522

```
 12%|█▏       | 7/59 [00:24<03:06,  3.59s/it]
```

Number of matches 20463
Number of matches After Lowe's Ratio 285
Number of Robust matches 20

```
 14%|█▍       | 8/59 [00:28<03:12,  3.78s/it]
```

Number of matches 15850
Number of matches After Lowe's Ratio 710
Number of Robust matches 240

```
 15%|█▌       | 9/59 [00:32<03:02,  3.64s/it]
```

Number of matches 16465
Number of matches After Lowe's Ratio 1279
Number of Robust matches 469

```
 17%|█▋       | 10/59 [00:35<02:57,  3.61s/it]
```

Number of matches 17910

```
Number of matches After Lowe's Ratio 1820
Number of Robust matches 970


 19%|██         | 11/59 [00:39<02:55,  3.66s/it]

Number of matches 20488
Number of matches After Lowe's Ratio 3318
Number of Robust matches 2063


 20%|██         | 12/59 [00:43<02:56,  3.76s/it]

Number of matches 14865
Number of matches After Lowe's Ratio 2201
Number of Robust matches 1274


 22%|██         | 13/59 [00:46<02:37,  3.42s/it]

Number of matches 10652
Number of matches After Lowe's Ratio 909
Number of Robust matches 588


 24%|██         | 14/59 [00:48<02:14,  2.99s/it]

Number of matches 14443
Number of matches After Lowe's Ratio 738
Number of Robust matches 287


 25%|██         | 15/59 [00:50<02:06,  2.88s/it]

Number of matches 10456
Number of matches After Lowe's Ratio 1560
Number of Robust matches 1089


 27%|██         | 16/59 [00:52<01:55,  2.68s/it]

Number of matches 17715
Number of matches After Lowe's Ratio 925
Number of Robust matches 437


 29%|███        | 17/59 [00:56<02:04,  2.97s/it]

Number of matches 18284
Number of matches After Lowe's Ratio 4559
Number of Robust matches 2792


 31%|███        | 18/59 [01:00<02:11,  3.22s/it]

Number of matches 17764
Number of matches After Lowe's Ratio 4642
Number of Robust matches 3686


 32%|███        | 19/59 [01:04<02:14,  3.37s/it]

Number of matches 17499
Number of matches After Lowe's Ratio 3452
Number of Robust matches 2327
```

```
 34%|██           | 20/59 [01:07<02:13,  3.44s/it]
```

```
Number of matches 19138
Number of matches After Lowe's Ratio 3390
Number of Robust matches 2066
```

```
 36%|███          | 21/59 [01:11<02:18,  3.66s/it]
```

```
Number of matches 21978
Number of matches After Lowe's Ratio 2254
Number of Robust matches 1418
```

```
 37%|███          | 22/59 [01:16<02:28,  4.02s/it]
```

```
Number of matches 23315
Number of matches After Lowe's Ratio 4014
Number of Robust matches 2508
```

```
 39%|███          | 23/59 [01:22<02:39,  4.44s/it]
```

```
Number of matches 25930
Number of matches After Lowe's Ratio 4024
Number of Robust matches 2036
```

```
 41%|████         | 24/59 [01:28<02:50,  4.87s/it]
```

```
Number of matches 25725
Number of matches After Lowe's Ratio 4067
Number of Robust matches 2403
```

```
 42%|████         | 25/59 [01:33<02:53,  5.09s/it]
```

```
Number of matches 25272
Number of matches After Lowe's Ratio 3528
Number of Robust matches 1898
```

```
 44%|████         | 26/59 [01:39<02:52,  5.23s/it]
```

```
Number of matches 23716
Number of matches After Lowe's Ratio 4479
Number of Robust matches 2066
```

```
 46%|█████        | 27/59 [01:44<02:45,  5.16s/it]
```

```
Number of matches 21541
Number of matches After Lowe's Ratio 3016
Number of Robust matches 1393
```

```
 47%|█████        | 28/59 [01:48<02:33,  4.94s/it]
```

```
Number of matches 20126
Number of matches After Lowe's Ratio 4412
Number of Robust matches 2017
```

```
 49%|█████        | 29/59 [01:52<02:21,  4.73s/it]
```

```
Number of matches 18854
```

```
Number of matches After Lowe's Ratio 3617
Number of Robust matches 1334


 51%|██████        | 30/59 [01:56<02:09,  4.45s/it]

Number of matches 17303
Number of matches After Lowe's Ratio 2813
Number of Robust matches 1145


 53%|██████        | 31/59 [02:00<01:58,  4.23s/it]

Number of matches 18642
Number of matches After Lowe's Ratio 2306
Number of Robust matches 1142


 54%|██████        | 32/59 [02:04<01:55,  4.27s/it]

Number of matches 27086
Number of matches After Lowe's Ratio 575
Number of Robust matches 151


 56%|██████        | 33/59 [02:10<02:03,  4.76s/it]

Number of matches 22491
Number of matches After Lowe's Ratio 1515
Number of Robust matches 698


 58%|██████        | 34/59 [02:16<02:04,  4.96s/it]

Number of matches 31012
Number of matches After Lowe's Ratio 252
Number of Robust matches 10


 59%|██████        | 35/59 [02:22<02:11,  5.49s/it]

Number of matches 24213
Number of matches After Lowe's Ratio 852
Number of Robust matches 290


 61%|███████       | 36/59 [02:28<02:05,  5.44s/it]

Number of matches 22667
Number of matches After Lowe's Ratio 3745
Number of Robust matches 1617


 63%|███████       | 37/59 [02:32<01:55,  5.25s/it]

Number of matches 19376
Number of matches After Lowe's Ratio 2972
Number of Robust matches 1375


 64%|███████       | 38/59 [02:37<01:43,  4.92s/it]

Number of matches 18221
Number of matches After Lowe's Ratio 2124
Number of Robust matches 844
```

```
 66%|███████    | 39/59 [02:41<01:32,  4.63s/it]
```

Number of matches 19609
Number of matches After Lowe's Ratio 2255
Number of Robust matches 710

```
 68%|████████   | 40/59 [02:45<01:24,  4.46s/it]
```

Number of matches 19236
Number of matches After Lowe's Ratio 2151
Number of Robust matches 747

```
 69%|████████   | 41/59 [02:49<01:17,  4.31s/it]
```

Number of matches 18754
Number of matches After Lowe's Ratio 4362
Number of Robust matches 1678

```
 71%|████████   | 42/59 [02:53<01:11,  4.21s/it]
```

Number of matches 20522
Number of matches After Lowe's Ratio 1987
Number of Robust matches 812

```
 73%|████████   | 43/59 [02:57<01:08,  4.27s/it]
```

Number of matches 20368
Number of matches After Lowe's Ratio 2038
Number of Robust matches 1016

```
 75%|████████   | 44/59 [03:01<01:04,  4.28s/it]
```

Number of matches 19692
Number of matches After Lowe's Ratio 2986
Number of Robust matches 1445

```
 76%|████████   | 45/59 [03:05<00:59,  4.23s/it]
```

Number of matches 17996
Number of matches After Lowe's Ratio 2158
Number of Robust matches 1047

```
 78%|████████   | 46/59 [03:09<00:53,  4.14s/it]
```

Number of matches 17038
Number of matches After Lowe's Ratio 1663
Number of Robust matches 1254

```
 80%|████████   | 47/59 [03:13<00:48,  4.01s/it]
```

Number of matches 17238
Number of matches After Lowe's Ratio 2289
Number of Robust matches 1571

```
 81%|████████   | 48/59 [03:17<00:43,  3.96s/it]
```

```
Number of matches 16004
Number of matches After Lowe's Ratio 2106
Number of Robust matches 1224


  83%|████████  | 49/59 [03:20<00:37,  3.76s/it]

Number of matches 15671
Number of matches After Lowe's Ratio 4305
Number of Robust matches 2753


  85%|████████  | 50/59 [03:23<00:32,  3.60s/it]

Number of matches 16163
Number of matches After Lowe's Ratio 1985
Number of Robust matches 1027


  86%|████████  | 51/59 [03:27<00:27,  3.50s/it]

Number of matches 16142
Number of matches After Lowe's Ratio 4358
Number of Robust matches 2662


  88%|████████  | 52/59 [03:30<00:23,  3.36s/it]

Number of matches 8007
Number of matches After Lowe's Ratio 394
Number of Robust matches 158


  90%|█████████ | 53/59 [03:31<00:16,  2.76s/it]

Number of matches 6211
Number of matches After Lowe's Ratio 1367
Number of Robust matches 561


  92%|█████████ | 54/59 [03:32<00:11,  2.24s/it]

Number of matches 6223
Number of matches After Lowe's Ratio 703
Number of Robust matches 273


  93%|█████████ | 55/59 [03:33<00:07,  1.87s/it]

Number of matches 7000
Number of matches After Lowe's Ratio 1682
Number of Robust matches 1001


  95%|█████████ | 56/59 [03:34<00:05,  1.73s/it]

Number of matches 12304
Number of matches After Lowe's Ratio 1012
Number of Robust matches 491


  97%|█████████ | 57/59 [03:37<00:03,  1.95s/it]

Number of matches 15735
Number of matches After Lowe's Ratio 3365
Number of Robust matches 2127
```

```
Number of matches 15790
Number of matches After Lowe's Ratio 3217
Number of Robust matches 1970
```

In [44]:

```python
amax,amin,zmax,zmin,d,i,q,ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_daisy,H_right_daisy)
```

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

In [45]:

```python
warp_image_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_daisy,amax,ami
n,zmax,zmin,d,i,q,ht)
```

```
step31:Done
```

In [46]:

```python
warp_imgs_all_daisy = final_step_right_union(warp_image_left,images_right_bgr_no_enhance,
H_right_daisy,amax,amin,zmax,zmin,d,i,q,ht)
```
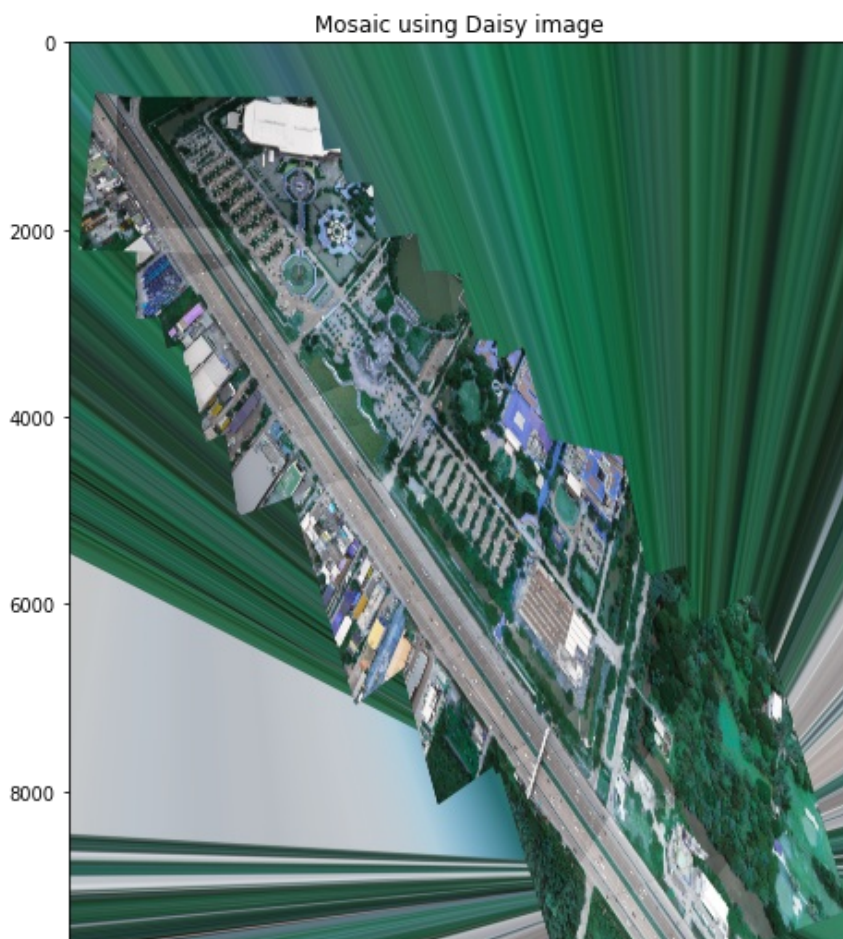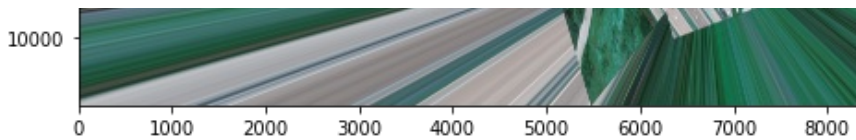
```
step32:Done
```

In [47]:

```python
plt.figure(figsize=(20,10))
plt.imshow(warp_imgs_all_daisy)
plt.title('Mosaic using Daisy image')
```

Out[47]:

```
Text(0.5, 1.0, 'Mosaic using Daisy image')
```

For Star 110 images

```python
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 [00:07<00:00,  6.60it/s]
100%|██████████| 59/59 [00:09<00:00,  6.39it/s]
```

In [31]:

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

```
100%|██████████| 110/110 [00:00<00:00, 62322.50it/s]
```

In [32]:

```python
H_left_star = []
H_right_star = []

num_matches_star = []
num_good_matches_star = []

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

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

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

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
```

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

  2%|▏ | 1/51 [00:00<00:10, 4.76it/s]

Number of matches 6815
Number of matches After Lowe's Ratio 686
Number of Robust matches 312

  4%|▎ | 2/51 [00:00<00:10, 4.50it/s]

Number of matches 6920
Number of matches After Lowe's Ratio 392
Number of Robust matches 8

  6%|▌ | 3/51 [00:00<00:12, 3.84it/s]

Number of matches 7081
Number of matches After Lowe's Ratio 460
Number of Robust matches 92

  8%|▋ | 4/51 [00:01<00:11, 3.98it/s]

Number of matches 7254
Number of matches After Lowe's Ratio 709
Number of Robust matches 265

 10%|▉ | 5/51 [00:01<00:11, 4.05it/s]

Number of matches 6568
Number of matches After Lowe's Ratio 721
Number of Robust matches 351

 12%|█ | 6/51 [00:01<00:10, 4.23it/s]

Number of matches 6520
Number of matches After Lowe's Ratio 667
Number of Robust matches 276

Number of matches 6098
Number of matches After Lowe's Ratio 737
 16%|█▌ | 8/51 [00:01<00:09, 4.69it/s]

Number of Robust matches 392

Number of matches 6281
Number of matches After Lowe's Ratio 1387
Number of Robust matches 959

 18%|█▊ | 9/51 [00:02<00:08, 4.74it/s]

Number of matches 5984
Number of matches After Lowe's Ratio 1173
Number of Robust matches 764

```
Number of matches 6106
Number of matches After Lowe's Ratio 775
```

```
Number of Robust matches 385
```

```
Number of matches 6128
Number of matches After Lowe's Ratio 462
```

```
Number of Robust matches 102
```

```
Number of matches 5937
Number of matches After Lowe's Ratio 940
Number of Robust matches 486
```

```
Number of matches 6776
Number of matches After Lowe's Ratio 549
Number of Robust matches 101
```

```
Number of matches 6634
Number of matches After Lowe's Ratio 879
Number of Robust matches 364
```

```
Number of matches 7698
Number of matches After Lowe's Ratio 435
Number of Robust matches 8
```

```
Number of matches 6518
Number of matches After Lowe's Ratio 370
Number of Robust matches 6
```

```
Number of matches 7166
Number of matches After Lowe's Ratio 780
Number of Robust matches 247
```

```
Number of matches 6884
Number of matches After Lowe's Ratio 422
Number of Robust matches 9
```

```
Number of matches 8652
Number of matches After Lowe's Ratio 444
Number of Robust matches 6


 39%|███▌        | 20/51 [00:04<00:08,  3.66it/s]

Number of matches 8409
Number of matches After Lowe's Ratio 609
Number of Robust matches 93


 41%|███▊        | 21/51 [00:05<00:08,  3.54it/s]

Number of matches 8440
Number of matches After Lowe's Ratio 521
Number of Robust matches 29


 43%|████        | 22/51 [00:05<00:08,  3.47it/s]

Number of matches 6586
Number of matches After Lowe's Ratio 359
Number of Robust matches 6


 45%|████▎       | 23/51 [00:05<00:07,  3.79it/s]

Number of matches 6515
Number of matches After Lowe's Ratio 718
Number of Robust matches 254



Number of matches 5704
Number of matches After Lowe's Ratio 701
 49%|████▋       | 25/51 [00:05<00:05,  4.42it/s]

Number of Robust matches 270



Number of matches 6521
Number of matches After Lowe's Ratio 755
Number of Robust matches 247


 51%|█████       | 26/51 [00:06<00:06,  3.94it/s]

Number of matches 8904
Number of matches After Lowe's Ratio 816
Number of Robust matches 239


 53%|█████▏      | 27/51 [00:06<00:06,  3.69it/s]

Number of matches 10618
Number of matches After Lowe's Ratio 1219
Number of Robust matches 361


 55%|█████▍      | 28/51 [00:06<00:06,  3.30it/s]

Number of matches 11978
Number of matches After Lowe's Ratio 1417
Number of Robust matches 474
```

```
 57%|███████       | 29/51 [00:07<00:07,  2.97it/s]
```

Number of matches 10003
Number of matches After Lowe's Ratio 1266
Number of Robust matches 423

```
 59%|███████       | 30/51 [00:07<00:06,  3.03it/s]
```

Number of matches 8548
Number of matches After Lowe's Ratio 1161
Number of Robust matches 441

```
 61%|████████      | 31/51 [00:07<00:06,  3.19it/s]
```

Number of matches 7462
Number of matches After Lowe's Ratio 1278
Number of Robust matches 567

```
 63%|████████      | 32/51 [00:08<00:05,  3.47it/s]
```

Number of matches 6531
Number of matches After Lowe's Ratio 1199
Number of Robust matches 701

```
 65%|████████      | 33/51 [00:08<00:04,  3.74it/s]
```

Number of matches 6637
Number of matches After Lowe's Ratio 1187
Number of Robust matches 680

Number of matches 7057

```
 67%|█████████     | 34/51 [00:08<00:04,  4.01it/s]
```

Number of matches After Lowe's Ratio 1192
Number of Robust matches 697

```
 69%|█████████     | 35/51 [00:08<00:03,  4.14it/s]
```

Number of matches 7222
Number of matches After Lowe's Ratio 1240
Number of Robust matches 547

```
 71%|█████████     | 36/51 [00:09<00:03,  4.19it/s]
```

Number of matches 7095
Number of matches After Lowe's Ratio 1266
Number of Robust matches 643

```
 73%|█████████     | 37/51 [00:09<00:03,  4.26it/s]
```

Number of matches 6964
Number of matches After Lowe's Ratio 1046
Number of Robust matches 440

```
 75%|██████████    | 38/51 [00:09<00:03,  4.33it/s]
```

```
Number of matches 6391
Number of matches After Lowe's Ratio 696
Number of Robust matches 224


Number of matches 6220
Number of matches After Lowe's Ratio 1454
```

 76%|████████ | 39/51 [00:09<00:02, 4.56it/s]

```
Number of Robust matches 949
```

 78%|████████ | 40/51 [00:09<00:02, 4.20it/s]

```
Number of matches 6637
Number of matches After Lowe's Ratio 1135
Number of Robust matches 675


Number of matches 5955
Number of matches After Lowe's Ratio 871
```

 82%|████████ | 42/51 [00:10<00:01, 4.58it/s]

```
Number of Robust matches 471


Number of matches 6699
Number of matches After Lowe's Ratio 976
Number of Robust matches 520
```

 84%|████████ | 43/51 [00:10<00:01, 4.64it/s]

```
Number of matches 6684
Number of matches After Lowe's Ratio 1313
Number of Robust matches 816
```

 86%|████████ | 44/51 [00:10<00:01, 4.60it/s]

```
Number of matches 6654
Number of matches After Lowe's Ratio 565
Number of Robust matches 216
```

 88%|████████ | 45/51 [00:11<00:01, 4.63it/s]

```
Number of matches 6363
Number of matches After Lowe's Ratio 462
Number of Robust matches 139
```

 90%|████████ | 46/51 [00:11<00:01, 4.74it/s]

```
Number of matches 6030
Number of matches After Lowe's Ratio 678
Number of Robust matches 224


Number of matches 6742
Number of matches After Lowe's Ratio 675
```

 92%|████████ | 47/51 [00:11<00:00, 4.78it/s]

```
Number of Robust matches 211


 94%|████████▌ | 48/51 [00:11<00:00,  4.46it/s]

Number of matches 7144
Number of matches After Lowe's Ratio 625
Number of Robust matches 120


 96%|████████▋ | 49/51 [00:11<00:00,  4.29it/s]

Number of matches 7263
Number of matches After Lowe's Ratio 817
Number of Robust matches 201


  0%|          | 0/59 [00:00<?, ?it/s]

Number of matches 5783
Number of matches After Lowe's Ratio 317
Number of Robust matches 12


  2%|▏         | 1/59 [00:00<00:15,  3.75it/s]

Number of matches 5057
Number of matches After Lowe's Ratio 425
Number of Robust matches 110



Number of matches 7374
Number of matches After Lowe's Ratio 597
  3%|▎         | 2/59 [00:00<00:14,  4.06it/s]

Number of Robust matches 157


  5%|▌         | 3/59 [00:00<00:14,  3.93it/s]

Number of matches 6352
Number of matches After Lowe's Ratio 328
Number of Robust matches 26


  7%|▋         | 4/59 [00:00<00:13,  4.03it/s]

Number of matches 6567
Number of matches After Lowe's Ratio 451
Number of Robust matches 70


  8%|▊         | 5/59 [00:01<00:13,  4.01it/s]

Number of matches 6608
Number of matches After Lowe's Ratio 356
Number of Robust matches 17


 10%|█         | 6/59 [00:01<00:12,  4.14it/s]

Number of matches 6557
Number of matches After Lowe's Ratio 778
Number of Robust matches 288
```

```
 12%|█            | 7/59 [00:01<00:12,  4.05it/s]
```

Number of matches 7657
Number of matches After Lowe's Ratio 398
Number of Robust matches 8

```
 14%|█            | 8/59 [00:01<00:13,  3.91it/s]
```

Number of matches 5299
Number of matches After Lowe's Ratio 354
Number of Robust matches 11

```
 15%|█            | 9/59 [00:02<00:12,  4.05it/s]
```

Number of matches 5892
Number of matches After Lowe's Ratio 355
Number of Robust matches 28

```
 17%|█            | 10/59 [00:02<00:11,  4.19it/s]
```

Number of matches 6607
Number of matches After Lowe's Ratio 545
Number of Robust matches 134

```
 19%|█            | 11/59 [00:02<00:12,  3.89it/s]
```

Number of matches 7280
Number of matches After Lowe's Ratio 1035
Number of Robust matches 517

```
 20%|██           | 12/59 [00:02<00:11,  4.01it/s]
```

Number of matches 6308
Number of matches After Lowe's Ratio 1066
Number of Robust matches 590

Number of matches 5562
Number of matches After Lowe's Ratio 583

```
 22%|██           | 13/59 [00:03<00:10,  4.29it/s]
```

Number of Robust matches 262

Number of matches 6545
Number of matches After Lowe's Ratio 471

```
 25%|██           | 15/59 [00:03<00:09,  4.53it/s]
```

Number of Robust matches 61

Number of matches 5071
Number of matches After Lowe's Ratio 646
Number of Robust matches 341

```
 27%|██           | 16/59 [00:03<00:09,  4.78it/s]
```

```
Number of matches 7030
Number of matches After Lowe's Ratio 618
Number of Robust matches 225
```

```
 29%|██        | 17/59 [00:03<00:09,  4.66it/s]
```

```
Number of matches 6967
Number of matches After Lowe's Ratio 935
Number of Robust matches 488
```

```
 31%|██        | 18/59 [00:04<00:08,  4.62it/s]
```

```
Number of matches 6635
Number of matches After Lowe's Ratio 1012
Number of Robust matches 552
```

```
 34%|███       | 20/59 [00:04<00:08,  4.81it/s]
```

```
Number of matches 6187
Number of matches After Lowe's Ratio 1035
Number of Robust matches 614
```

```
Number of matches 6019
Number of matches After Lowe's Ratio 1246
Number of Robust matches 808
```

```
 36%|███       | 21/59 [00:04<00:07,  4.84it/s]
```

```
Number of matches 6759
Number of matches After Lowe's Ratio 660
Number of Robust matches 232
```

```
 37%|███       | 22/59 [00:05<00:07,  4.75it/s]
```

```
Number of matches 7354
Number of matches After Lowe's Ratio 884
Number of Robust matches 377
```

```
 39%|███       | 23/59 [00:05<00:08,  4.48it/s]
```

```
Number of matches 7852
Number of matches After Lowe's Ratio 855
Number of Robust matches 361
```

```
 41%|████      | 24/59 [00:05<00:08,  4.18it/s]
```

```
Number of matches 8426
Number of matches After Lowe's Ratio 867
Number of Robust matches 273
```

```
 42%|████      | 25/59 [00:05<00:08,  3.88it/s]
```

```
Number of matches 8569
Number of matches After Lowe's Ratio 684
Number of Robust matches 172
```

```
 44%|████     | 26/59 [00:06<00:08,  3.75it/s]

Number of matches 7887
Number of matches After Lowe's Ratio 918
Number of Robust matches 326


 46%|████     | 27/59 [00:06<00:08,  3.68it/s]

Number of matches 7352
Number of matches After Lowe's Ratio 876
Number of Robust matches 267


 47%|████     | 28/59 [00:06<00:08,  3.79it/s]

Number of matches 7423
Number of matches After Lowe's Ratio 1122
Number of Robust matches 395


 49%|████     | 29/59 [00:06<00:07,  3.85it/s]

Number of matches 6930
Number of matches After Lowe's Ratio 1106
Number of Robust matches 318


 51%|█████    | 30/59 [00:07<00:08,  3.48it/s]

Number of matches 6894
Number of matches After Lowe's Ratio 589
Number of Robust matches 113


 53%|█████    | 31/59 [00:07<00:07,  3.51it/s]

Number of matches 6802
Number of matches After Lowe's Ratio 570
Number of Robust matches 121


 54%|█████    | 32/59 [00:07<00:07,  3.50it/s]

Number of matches 10547
Number of matches After Lowe's Ratio 544
Number of Robust matches 6


 56%|█████    | 33/59 [00:08<00:08,  3.15it/s]

Number of matches 9644
Number of matches After Lowe's Ratio 770
Number of Robust matches 145


 58%|██████   | 34/59 [00:08<00:08,  3.02it/s]

Number of matches 10942
Number of matches After Lowe's Ratio 617
Number of Robust matches 5


 59%|██████   | 35/59 [00:09<00:08,  2.85it/s]

Number of matches 8681
```

Number of matches After Lowe's Ratio 750
Number of Robust matches 101

```
 61%|███████     | 36/59 [00:09<00:07,  2.94it/s]
```

Number of matches 7457
Number of matches After Lowe's Ratio 663
Number of Robust matches 70

```
 63%|███████     | 37/59 [00:09<00:06,  3.15it/s]
```

Number of matches 6732
Number of matches After Lowe's Ratio 990
Number of Robust matches 255

```
 64%|███████     | 38/59 [00:09<00:06,  3.35it/s]
```

Number of matches 6593
Number of matches After Lowe's Ratio 611
Number of Robust matches 143

```
 66%|███████     | 39/59 [00:10<00:05,  3.50it/s]
```

Number of matches 7130
Number of matches After Lowe's Ratio 751
Number of Robust matches 128

```
 68%|███████     | 40/59 [00:10<00:05,  3.60it/s]
```

Number of matches 7516
Number of matches After Lowe's Ratio 895
Number of Robust matches 249

```
 69%|███████     | 41/59 [00:10<00:04,  3.74it/s]
```

Number of matches 7371
Number of matches After Lowe's Ratio 1512
Number of Robust matches 565

```
 71%|███████     | 42/59 [00:10<00:04,  3.80it/s]
```

Number of matches 7839
Number of matches After Lowe's Ratio 838
Number of Robust matches 253

```
 73%|███████     | 43/59 [00:11<00:04,  3.71it/s]
```

Number of matches 7208
Number of matches After Lowe's Ratio 421
Number of Robust matches 6

```
 75%|███████     | 44/59 [00:11<00:04,  3.45it/s]
```

Number of matches 6916
Number of matches After Lowe's Ratio 658
Number of Robust matches 180

```
 76%|███████   | 45/59 [00:11<00:03,  3.65it/s]
```

Number of matches 6160
Number of matches After Lowe's Ratio 596
Number of Robust matches 172

```
 78%|███████   | 46/59 [00:11<00:03,  3.93it/s]
```

Number of matches 5951
Number of matches After Lowe's Ratio 479
Number of Robust matches 150

Number of matches 6068
Number of matches After Lowe's Ratio 580

```
 81%|████████  | 48/59 [00:12<00:02,  4.48it/s]
```

Number of Robust matches 229

Number of matches 5391
Number of matches After Lowe's Ratio 533
Number of Robust matches 179

```
 85%|████████  | 50/59 [00:12<00:01,  5.00it/s]
```

Number of matches 5254
Number of matches After Lowe's Ratio 1084
Number of Robust matches 650

Number of matches 5981
Number of matches After Lowe's Ratio 676
Number of Robust matches 218

```
 88%|████████  | 52/59 [00:13<00:01,  5.35it/s]
```

Number of matches 5843
Number of matches After Lowe's Ratio 897
Number of Robust matches 446

Number of matches 3483
Number of matches After Lowe's Ratio 416
Number of Robust matches 218

```
 93%|█████████ | 55/59 [00:13<00:00,  7.00it/s]
```

Number of matches 2951
Number of matches After Lowe's Ratio 410
Number of Robust matches 192

Number of matches 2836
Number of matches After Lowe's Ratio 365
Number of Robust matches 194

```
Number of matches 2993
Number of matches After Lowe's Ratio 525
Number of Robust matches 261
```

 97%|█████████ | 57/59 [00:13<00:00, 6.78it/s]

```
Number of matches 5209
Number of matches After Lowe's Ratio 619
Number of Robust matches 329
```

```
Number of matches 6095
Number of matches After Lowe's Ratio 1007
Number of Robust matches 539
```

 98%|█████████ | 58/59 [00:13<00:00, 6.20it/s]

```
Number of matches 6031
Number of matches After Lowe's Ratio 1052
Number of Robust matches 527
```

In [35]:

```
xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_star,H_right_star)
```

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

In [36]:

```
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_star,xmax,xmin,
ymax,ymin,t,h,w,Ht)
```

```
step31:Done
```

In [37]:

```
warp_imgs_all_star = final_step_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_
right_star,xmax,xmin,ymax,ymin,t,h,w,Ht)
```

```
step32:Done
```

In [38]:

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

Out[38]:

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


120-Images Mosaic-STAR
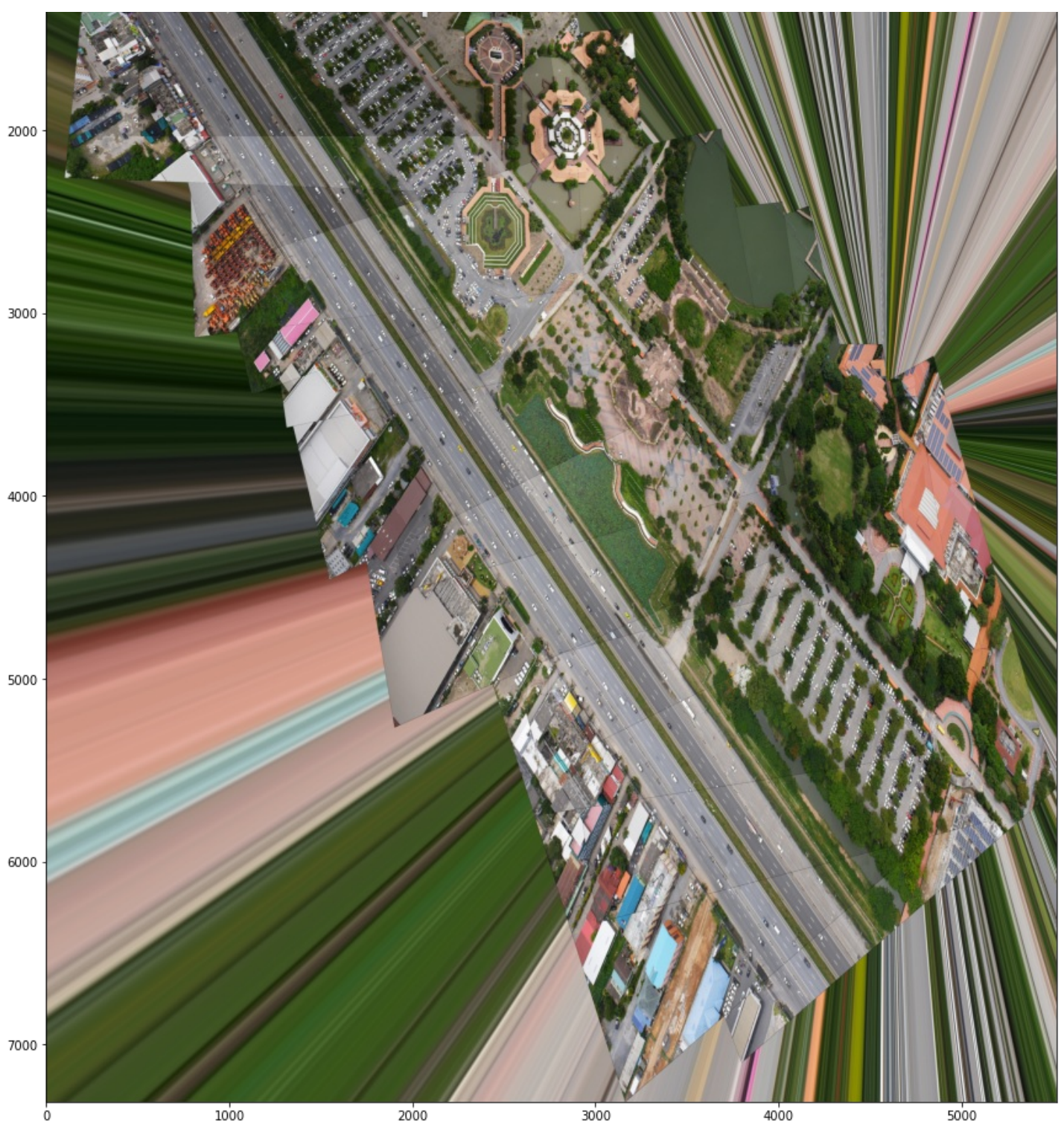
For Freak 110 image

```
Thresh1=60;
Octaves=8;
#PatternScales=1.0f;
brisk = cv2.BRISK_create(Thresh1,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]))
```

```
100%|██████████| 51/51 [00:42<00:00,  1.21it/s]
100%|██████████| 59/59 [00:42<00:00,  1.38it/s]
```

In [16]:

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

```
100%|██████████| 110/110 [00:00<00:00, 45370.58it/s]
```

In [20]:

```
H_left_freak = []
H_right_freak = []

num_matches_freak = []
num_good_matches_freak = []

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

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

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

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

```
  2%|          | 1/51 [00:02<01:46,  2.14s/it]
```

```
Number of matches 30963
Number of matches After Lowe's Ratio 1970
Number of Robust matches 998
```

```
  4%|          | 2/51 [00:04<01:52,  2.30s/it]
```

```
Number of matches 30334
Number of matches After Lowe's Ratio 1980
Number of Robust matches 1083
```

```
  6%|          | 3/51 [00:07<01:59,  2.48s/it]
```

```
Number of matches 35225
Number of matches After Lowe's Ratio 2068
```

```
Number of Robust matches 1011


 8%|█        | 4/51 [00:10<02:06,  2.70s/it]

Number of matches 34588
Number of matches After Lowe's Ratio 2717
Number of Robust matches 1790


10%|█        | 5/51 [00:14<02:14,  2.92s/it]

Number of matches 32541
Number of matches After Lowe's Ratio 2194
Number of Robust matches 1191


12%|█        | 6/51 [00:17<02:13,  2.97s/it]

Number of matches 28721
Number of matches After Lowe's Ratio 2154
Number of Robust matches 1283


14%|█        | 7/51 [00:19<02:04,  2.83s/it]

Number of matches 30225
Number of matches After Lowe's Ratio 2180
Number of Robust matches 1260


16%|█        | 8/51 [00:23<02:04,  2.90s/it]

Number of matches 30991
Number of matches After Lowe's Ratio 2562
Number of Robust matches 1690


18%|█        | 9/51 [00:25<02:01,  2.90s/it]

Number of matches 29265
Number of matches After Lowe's Ratio 2753
Number of Robust matches 1811


20%|██       | 10/51 [00:28<01:56,  2.85s/it]

Number of matches 29356
Number of matches After Lowe's Ratio 2185
Number of Robust matches 1215


22%|██       | 11/51 [00:31<01:54,  2.86s/it]

Number of matches 30010
Number of matches After Lowe's Ratio 1740
Number of Robust matches 848


24%|██       | 12/51 [00:34<01:47,  2.77s/it]

Number of matches 29570
Number of matches After Lowe's Ratio 1905
Number of Robust matches 832
```

```
 25%|██          | 13/51 [00:36<01:43,  2.71s/it]
```

Number of matches 30831
Number of matches After Lowe's Ratio 2026
Number of Robust matches 1013

```
 27%|██          | 14/51 [00:39<01:42,  2.76s/it]
```

Number of matches 33305
Number of matches After Lowe's Ratio 1784
Number of Robust matches 824

```
 29%|██          | 15/51 [00:43<01:48,  3.01s/it]
```

Number of matches 41880
Number of matches After Lowe's Ratio 1848
Number of Robust matches 594

```
 31%|███         | 16/51 [00:47<01:56,  3.32s/it]
```

Number of matches 35904
Number of matches After Lowe's Ratio 1773
Number of Robust matches 534

```
 33%|███         | 17/51 [00:50<01:52,  3.29s/it]
```

Number of matches 30389
Number of matches After Lowe's Ratio 1638
Number of Robust matches 593

```
 35%|███         | 18/51 [00:52<01:41,  3.07s/it]
```

Number of matches 28704
Number of matches After Lowe's Ratio 1350
Number of Robust matches 383

```
 37%|████        | 19/51 [00:55<01:33,  2.92s/it]
```

Number of matches 31542
Number of matches After Lowe's Ratio 999
Number of Robust matches 224

```
 39%|████        | 20/51 [00:58<01:30,  2.93s/it]
```

Number of matches 31853
Number of matches After Lowe's Ratio 1341
Number of Robust matches 459

```
 41%|████        | 21/51 [01:01<01:27,  2.90s/it]
```

Number of matches 32825
Number of matches After Lowe's Ratio 818
Number of Robust matches 149

```
 43%|█████       | 22/51 [01:03<01:21,  2.82s/it]
```

Number of matches 22605
Number of matches After Lowe's Ratio 526

```
Number of Robust matches 10
```

```
 45%|████      | 23/51 [01:05<01:11,  2.55s/it]
```

```
Number of matches 23139
Number of matches After Lowe's Ratio 1355
Number of Robust matches 464
```

```
 47%|████▌     | 24/51 [01:07<01:02,  2.31s/it]
```

```
Number of matches 19638
Number of matches After Lowe's Ratio 1291
Number of Robust matches 501
```

```
 49%|████▉     | 25/51 [01:09<00:54,  2.08s/it]
```

```
Number of matches 24280
Number of matches After Lowe's Ratio 1278
Number of Robust matches 475
```

```
 51%|█████     | 26/51 [01:11<00:52,  2.10s/it]
```

```
Number of matches 29286
Number of matches After Lowe's Ratio 1589
Number of Robust matches 514
```

```
 53%|█████▎    | 27/51 [01:14<00:58,  2.44s/it]
```

```
Number of matches 41948
Number of matches After Lowe's Ratio 1685
Number of Robust matches 448
```

```
 55%|█████▍    | 28/51 [01:19<01:10,  3.08s/it]
```

```
Number of matches 45777
Number of matches After Lowe's Ratio 2087
Number of Robust matches 616
```

```
 57%|█████▋    | 29/51 [01:23<01:19,  3.61s/it]
```

```
Number of matches 41498
Number of matches After Lowe's Ratio 1885
Number of Robust matches 539
```

```
 59%|█████▉    | 30/51 [01:27<01:17,  3.67s/it]
```

```
Number of matches 32765
Number of matches After Lowe's Ratio 1846
Number of Robust matches 689
```

```
 61%|██████    | 31/51 [01:30<01:09,  3.46s/it]
```

```
Number of matches 30811
Number of matches After Lowe's Ratio 2073
Number of Robust matches 1017
```

```
 63%|███████      | 32/51 [01:33<01:01,  3.22s/it]
```

Number of matches 28921
Number of matches After Lowe's Ratio 2098
Number of Robust matches 1031

```
 65%|███████      | 33/51 [01:35<00:53,  2.98s/it]
```

Number of matches 28541
Number of matches After Lowe's Ratio 2295
Number of Robust matches 1286

```
 67%|███████      | 34/51 [01:38<00:49,  2.90s/it]
```

Number of matches 34315
Number of matches After Lowe's Ratio 2270
Number of Robust matches 1120

```
 69%|███████      | 35/51 [01:41<00:48,  3.04s/it]
```

Number of matches 37159
Number of matches After Lowe's Ratio 2652
Number of Robust matches 1232

```
 71%|████████     | 36/51 [01:45<00:47,  3.17s/it]
```

Number of matches 35439
Number of matches After Lowe's Ratio 2555
Number of Robust matches 1194

```
 73%|████████     | 37/51 [01:48<00:45,  3.25s/it]
```

Number of matches 36939
Number of matches After Lowe's Ratio 2534
Number of Robust matches 1110

```
 75%|████████     | 38/51 [01:52<00:42,  3.30s/it]
```

Number of matches 30760
Number of matches After Lowe's Ratio 1631
Number of Robust matches 762

```
 76%|████████     | 39/51 [01:54<00:36,  3.08s/it]
```

Number of matches 29514
Number of matches After Lowe's Ratio 2922
Number of Robust matches 1733

```
 78%|████████     | 40/51 [01:57<00:32,  2.94s/it]
```

Number of matches 28402
Number of matches After Lowe's Ratio 2484
Number of Robust matches 1502

```
 80%|████████     | 41/51 [01:59<00:27,  2.77s/it]
```

Number of matches 25855
Number of matches After Lowe's Ratio 1480

Number of matches After Lowe's Ratio 1480
Number of Robust matches 693


```
 82%|███████▋  | 42/51 [02:01<00:23,  2.58s/it]
```

Number of matches 25442
Number of matches After Lowe's Ratio 1495
Number of Robust matches 756


```
 84%|███████▊  | 43/51 [02:04<00:19,  2.47s/it]
```

Number of matches 25540
Number of matches After Lowe's Ratio 1955
Number of Robust matches 1092


```
 86%|████████▍ | 44/51 [02:06<00:16,  2.42s/it]
```

Number of matches 31109
Number of matches After Lowe's Ratio 1898
Number of Robust matches 849


```
 88%|████████▋ | 45/51 [02:08<00:14,  2.46s/it]
```

Number of matches 25420
Number of matches After Lowe's Ratio 1816
Number of Robust matches 903


```
 90%|████████▊ | 46/51 [02:11<00:11,  2.37s/it]
```

Number of matches 27131
Number of matches After Lowe's Ratio 1686
Number of Robust matches 591


```
 92%|█████████▏| 47/51 [02:13<00:09,  2.40s/it]
```

Number of matches 30777
Number of matches After Lowe's Ratio 2543
Number of Robust matches 944


```
 94%|█████████▍| 48/51 [02:16<00:07,  2.54s/it]
```

Number of matches 31215
Number of matches After Lowe's Ratio 1660
Number of Robust matches 497


```
 96%|█████████▌| 49/51 [02:19<00:05,  2.70s/it]
```

Number of matches 34016
Number of matches After Lowe's Ratio 2589
Number of Robust matches 759


```
  0%|          | 0/59 [00:00<?, ?it/s]
```

Number of matches 23270
Number of matches After Lowe's Ratio 855
Number of Robust matches 141

```
  2%|          | 1/59 [00:02<02:09,  2.24s/it]
```

Number of matches 20799
Number of matches After Lowe's Ratio 1348
Number of Robust matches 691

```
  3%|          | 2/59 [00:03<01:59,  2.09s/it]
```

Number of matches 29762
Number of matches After Lowe's Ratio 1249
Number of Robust matches 394

```
  5%|          | 3/59 [00:06<02:05,  2.24s/it]
```

Number of matches 24534
Number of matches After Lowe's Ratio 1502
Number of Robust matches 695

```
  7%|          | 4/59 [00:08<02:00,  2.19s/it]
```

Number of matches 26179
Number of matches After Lowe's Ratio 1573
Number of Robust matches 507

```
  8%|          | 5/59 [00:10<01:55,  2.14s/it]
```

Number of matches 21791
Number of matches After Lowe's Ratio 1382
Number of Robust matches 582

```
 10%|          | 6/59 [00:12<01:47,  2.03s/it]
```

Number of matches 23985
Number of matches After Lowe's Ratio 1392
Number of Robust matches 503

```
 12%|          | 7/59 [00:14<01:47,  2.06s/it]
```

Number of matches 29091
Number of matches After Lowe's Ratio 737
Number of Robust matches 9

```
 14%|          | 8/59 [00:16<01:49,  2.14s/it]
```

Number of matches 23038
Number of matches After Lowe's Ratio 773
Number of Robust matches 177

```
 15%|          | 9/59 [00:18<01:42,  2.04s/it]
```

Number of matches 21727
Number of matches After Lowe's Ratio 715
Number of Robust matches 162

```
 17%|          | 10/59 [00:20<01:35,  1.95s/it]
```

Number of matches 23257

```
Number of matches After Lowe's Ratio 896
Number of Robust matches 286


  19%|██          | 11/59 [00:22<01:38,  2.04s/it]

Number of matches 33002
Number of matches After Lowe's Ratio 1650
Number of Robust matches 703


  20%|██          | 12/59 [00:25<01:45,  2.25s/it]

Number of matches 26873
Number of matches After Lowe's Ratio 1877
Number of Robust matches 1132


  22%|██          | 13/59 [00:27<01:41,  2.22s/it]

Number of matches 24439
Number of matches After Lowe's Ratio 1088
Number of Robust matches 496


  24%|██          | 14/59 [00:29<01:35,  2.13s/it]

Number of matches 22762
Number of matches After Lowe's Ratio 660
Number of Robust matches 171


  25%|███         | 15/59 [00:31<01:30,  2.05s/it]

Number of matches 19743
Number of matches After Lowe's Ratio 1429
Number of Robust matches 876


  27%|███         | 16/59 [00:33<01:23,  1.94s/it]

Number of matches 29263
Number of matches After Lowe's Ratio 1191
Number of Robust matches 440


  29%|███         | 17/59 [00:35<01:30,  2.14s/it]

Number of matches 29662
Number of matches After Lowe's Ratio 2303
Number of Robust matches 1531


  31%|███         | 18/59 [00:38<01:36,  2.36s/it]

Number of matches 31340
Number of matches After Lowe's Ratio 2415
Number of Robust matches 1565


  32%|███         | 19/59 [00:41<01:40,  2.50s/it]

Number of matches 28069
Number of matches After Lowe's Ratio 1957
Number of Robust matches 1297
```

```
 34%|███         | 20/59 [00:43<01:38,  2.52s/it]
```

Number of matches 30957
Number of matches After Lowe's Ratio 2203
Number of Robust matches 1468

```
 36%|████        | 21/59 [00:46<01:40,  2.64s/it]
```

Number of matches 30565
Number of matches After Lowe's Ratio 1710
Number of Robust matches 932

```
 37%|████        | 22/59 [00:49<01:39,  2.69s/it]
```

Number of matches 32974
Number of matches After Lowe's Ratio 2144
Number of Robust matches 1194

```
 39%|████        | 23/59 [00:52<01:40,  2.80s/it]
```

Number of matches 36549
Number of matches After Lowe's Ratio 2049
Number of Robust matches 1035

```
 41%|████        | 24/59 [00:56<01:45,  3.02s/it]
```

Number of matches 35159
Number of matches After Lowe's Ratio 2159
Number of Robust matches 1048

```
 42%|█████       | 25/59 [00:59<01:47,  3.17s/it]
```

Number of matches 38169
Number of matches After Lowe's Ratio 2375
Number of Robust matches 1067

```
 44%|█████       | 26/59 [01:03<01:49,  3.31s/it]
```

Number of matches 33493
Number of matches After Lowe's Ratio 2166
Number of Robust matches 918

```
 46%|█████       | 27/59 [01:06<01:41,  3.17s/it]
```

Number of matches 27254
Number of matches After Lowe's Ratio 1758
Number of Robust matches 608

```
 47%|█████       | 28/59 [01:08<01:30,  2.92s/it]
```

Number of matches 29921
Number of matches After Lowe's Ratio 1991
Number of Robust matches 627

```
 49%|█████       | 29/59 [01:11<01:25,  2.85s/it]
```

Number of matches 27914

```
Number of matches 27911
Number of matches After Lowe's Ratio 1909
Number of Robust matches 524


 51%|██████      | 30/59 [01:13<01:17,  2.67s/it]

Number of matches 22382
Number of matches After Lowe's Ratio 1357
Number of Robust matches 472


 53%|██████      | 31/59 [01:15<01:07,  2.43s/it]

Number of matches 26806
Number of matches After Lowe's Ratio 1362
Number of Robust matches 510


 54%|██████      | 32/59 [01:18<01:08,  2.53s/it]

Number of matches 43407
Number of matches After Lowe's Ratio 896
Number of Robust matches 53


 56%|██████      | 33/59 [01:22<01:19,  3.07s/it]

Number of matches 39639
Number of matches After Lowe's Ratio 1050
Number of Robust matches 276


 58%|██████      | 34/59 [01:26<01:25,  3.42s/it]

Number of matches 44415
Number of matches After Lowe's Ratio 776
Number of Robust matches 6


 59%|██████      | 35/59 [01:30<01:28,  3.67s/it]

Number of matches 34575
Number of matches After Lowe's Ratio 999
Number of Robust matches 182


 61%|███████     | 36/59 [01:34<01:21,  3.53s/it]

Number of matches 32318
Number of matches After Lowe's Ratio 1710
Number of Robust matches 528


 63%|███████     | 37/59 [01:37<01:13,  3.33s/it]

Number of matches 30468
Number of matches After Lowe's Ratio 1780
Number of Robust matches 501


 64%|███████     | 38/59 [01:39<01:06,  3.16s/it]

Number of matches 26838
Number of matches After Lowe's Ratio 1500
Number of Robust matches 407
```

```
 66%|███████     | 39/59 [01:41<00:57,  2.86s/it]
```

Number of matches 24184
Number of matches After Lowe's Ratio 1182
Number of Robust matches 290

```
 68%|███████▋    | 40/59 [01:44<00:49,  2.61s/it]
```

Number of matches 25941
Number of matches After Lowe's Ratio 1171
Number of Robust matches 287

```
 69%|███████▊    | 41/59 [01:46<00:45,  2.54s/it]
```

Number of matches 27985
Number of matches After Lowe's Ratio 2156
Number of Robust matches 659

```
 71%|████████    | 42/59 [01:48<00:43,  2.54s/it]
```

Number of matches 29906
Number of matches After Lowe's Ratio 1365
Number of Robust matches 323

```
 73%|████████▏   | 43/59 [01:51<00:40,  2.54s/it]
```

Number of matches 26647
Number of matches After Lowe's Ratio 1665
Number of Robust matches 590

```
 75%|████████▍   | 44/59 [01:53<00:37,  2.51s/it]
```

Number of matches 30823
Number of matches After Lowe's Ratio 1779
Number of Robust matches 579

```
 76%|████████▋   | 45/59 [01:56<00:35,  2.52s/it]
```

Number of matches 23861
Number of matches After Lowe's Ratio 1320
Number of Robust matches 511

```
 78%|████████▊   | 46/59 [01:58<00:30,  2.37s/it]
```

Number of matches 26390
Number of matches After Lowe's Ratio 1020
Number of Robust matches 488

```
 80%|█████████   | 47/59 [02:00<00:27,  2.32s/it]
```

Number of matches 26937
Number of matches After Lowe's Ratio 1289
Number of Robust matches 735

```
 81%|█████████▏  | 48/59 [02:03<00:25,  2.34s/it]
```

```
Number of matches 26134
Number of matches After Lowe's Ratio 1195
Number of Robust matches 629


 83%|████████   | 49/59 [02:05<00:22,  2.27s/it]

Number of matches 23810
Number of matches After Lowe's Ratio 1941
Number of Robust matches 1211


 85%|████████   | 50/59 [02:07<00:19,  2.16s/it]

Number of matches 23843
Number of matches After Lowe's Ratio 1186
Number of Robust matches 522


 86%|████████   | 51/59 [02:08<00:16,  2.09s/it]

Number of matches 24045
Number of matches After Lowe's Ratio 2078
Number of Robust matches 1285


 88%|████████   | 52/59 [02:10<00:13,  1.99s/it]

Number of matches 12316
Number of matches After Lowe's Ratio 627
Number of Robust matches 277


 90%|█████████  | 53/59 [02:11<00:09,  1.61s/it]

Number of matches 8554
Number of matches After Lowe's Ratio 742
Number of Robust matches 417


 92%|█████████  | 54/59 [02:11<00:06,  1.28s/it]

Number of matches 9986
Number of matches After Lowe's Ratio 500
Number of Robust matches 256


 93%|█████████  | 55/59 [02:12<00:04,  1.08s/it]

Number of matches 11560
Number of matches After Lowe's Ratio 1186
Number of Robust matches 660


 95%|█████████  | 56/59 [02:13<00:02,  1.00it/s]

Number of matches 21160
Number of matches After Lowe's Ratio 1169
Number of Robust matches 549


 97%|█████████  | 57/59 [02:15<00:02,  1.21s/it]

Number of matches 24488
Number of matches After Lowe's Ratio 1811
Number of Robust matches 1005
```

```
 98%|███████▊| 58/59 [02:17<00:01,  1.48s/it]
```

```
Number of matches 23402
Number of matches After Lowe's Ratio 1687
Number of Robust matches 851
```

In [23]:

```python
omax,omin,umax,umin,T,H,W,HT = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_freak,H_right_freak)
```

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

In [ ]:

```python
warp_img = final_steps_left_union(images_left_bgr_no_enhance,H_left_freak,omax,omin,umax,
umin,T,H,W,HT)
```

In [ ]:

```python
warp_imgs_all_freak = final_step_right_union(warp_img,images_right_bgr_no_enhance,H_right
_freak,omax,omin,umax,umin,T,H,W,HT)
```

In [ ]:

```python
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')
```

For MSER 110 image

In [10]:

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

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


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

```
100%|████████| 51/51 [03:47<00:00,  4.45s/it]
100%|████████| 59/59 [05:07<00:00,  5.21s/it]
```

In [16]:

```python
num_kps_mser = []
```

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

```
100%|██████████| 110/110 [00:00<00:00, 49498.28it/s]
```

In [27]:

```
H_left_mser = []
H_right_mser = []

num_matches_mser = []
num_good_matches_mser = []

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

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

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

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

```
4%|█          | 2/51 [00:00<00:08,  6.08it/s]
```

```
Number of matches 1844
Number of matches After Lowe's Ratio 335
Number of Robust matches 157



Number of matches 1636
Number of matches After Lowe's Ratio 55
Number of Robust matches 21
```

```
6%|█          | 3/51 [00:00<00:08,  5.92it/s]
```

```
Number of matches 1977
Number of matches After Lowe's Ratio 172
Number of Robust matches 74



Number of matches 2022
Number of matches After Lowe's Ratio 292
```

```
10%|█          | 5/51 [00:00<00:08,  5.42it/s]
```

```
Number of Robust matches 173



Number of matches 1919
Number of matches After Lowe's Ratio 319
Number of Robust matches 202
```

```
12%|█          | 6/51 [00:01<00:08,  5.20it/s]
```

```
Number of matches 2101
Number of matches After Lowe's Ratio 339
Number of Robust matches 190
```

```
 14%|█▌          | 7/51 [00:01<00:08,  4.90it/s]
```

```
Number of matches 2304
Number of matches After Lowe's Ratio 447
Number of Robust matches 225
```

```
 16%|█▋          | 8/51 [00:01<00:09,  4.62it/s]
```

```
Number of matches 2185
Number of matches After Lowe's Ratio 630
Number of Robust matches 278
```

```
 18%|█▊          | 9/51 [00:01<00:09,  4.49it/s]
```

```
Number of matches 2208
Number of matches After Lowe's Ratio 663
Number of Robust matches 298
```

```
 20%|██          | 10/51 [00:02<00:09,  4.38it/s]
```

```
Number of matches 2367
Number of matches After Lowe's Ratio 486
Number of Robust matches 254
```

```
 22%|██▏         | 11/51 [00:02<00:09,  4.15it/s]
```

```
Number of matches 2393
Number of matches After Lowe's Ratio 267
Number of Robust matches 118
```

```
 24%|██▎         | 12/51 [00:02<00:09,  4.01it/s]
```

```
Number of matches 2359
Number of matches After Lowe's Ratio 540
Number of Robust matches 216
```

```
 25%|██▌         | 13/51 [00:02<00:09,  3.98it/s]
```

```
Number of matches 2461
Number of matches After Lowe's Ratio 307
Number of Robust matches 140
```

```
 27%|██▋         | 14/51 [00:03<00:09,  3.92it/s]
```

```
Number of matches 2249
Number of matches After Lowe's Ratio 470
Number of Robust matches 190
```

```
 29%|██▊         | 15/51 [00:03<00:08,  4.01it/s]
```

```
Number of matches 2372
Number of matches After Lowe's Ratio 8
Number of Robust matches 4
```

```
 31%|███          | 16/51 [00:03<00:08,  4.02it/s]
```

Number of matches 2069
Number of matches After Lowe's Ratio 41
Number of Robust matches 16

```
 33%|███          | 17/51 [00:03<00:08,  4.06it/s]
```

Number of matches 2359
Number of matches After Lowe's Ratio 501
Number of Robust matches 126

```
 35%|███          | 18/51 [00:04<00:08,  3.95it/s]
```

Number of matches 2766
Number of matches After Lowe's Ratio 65
Number of Robust matches 20

```
 37%|███          | 19/51 [00:04<00:08,  3.65it/s]
```

Number of matches 3058
Number of matches After Lowe's Ratio 46
Number of Robust matches 12

```
 39%|███          | 20/51 [00:04<00:09,  3.39it/s]
```

Number of matches 3085
Number of matches After Lowe's Ratio 406
Number of Robust matches 120

```
 41%|████         | 21/51 [00:05<00:09,  3.18it/s]
```

Number of matches 3255
Number of matches After Lowe's Ratio 245
Number of Robust matches 68

```
 43%|████         | 22/51 [00:05<00:09,  3.06it/s]
```

Number of matches 2861
Number of matches After Lowe's Ratio 8
Number of Robust matches 5

```
 45%|████         | 23/51 [00:05<00:09,  3.11it/s]
```

Number of matches 2662
Number of matches After Lowe's Ratio 454
Number of Robust matches 146

```
 47%|████         | 24/51 [00:06<00:08,  3.06it/s]
```

Number of matches 2577
Number of matches After Lowe's Ratio 536
Number of Robust matches 186

```
 49%|████         | 25/51 [00:06<00:08,  3.04it/s]
```

```
Number of matches 2927
Number of matches After Lowe's Ratio 444
Number of Robust matches 147


 51%|█████        | 26/51 [00:06<00:08,  2.97it/s]

Number of matches 3331
Number of matches After Lowe's Ratio 535
Number of Robust matches 169


 53%|██████       | 27/51 [00:07<00:08,  2.75it/s]

Number of matches 3499
Number of matches After Lowe's Ratio 487
Number of Robust matches 135


 55%|██████       | 28/51 [00:07<00:08,  2.59it/s]

Number of matches 3895
Number of matches After Lowe's Ratio 731
Number of Robust matches 259


 57%|██████       | 29/51 [00:08<00:08,  2.45it/s]

Number of matches 3345
Number of matches After Lowe's Ratio 623
Number of Robust matches 225


 59%|███████      | 30/51 [00:08<00:08,  2.50it/s]

Number of matches 2826
Number of matches After Lowe's Ratio 638
Number of Robust matches 232


 61%|███████      | 31/51 [00:08<00:07,  2.68it/s]

Number of matches 2607
Number of matches After Lowe's Ratio 617
Number of Robust matches 235


 63%|███████      | 32/51 [00:09<00:06,  2.89it/s]

Number of matches 2230
Number of matches After Lowe's Ratio 519
Number of Robust matches 236


 65%|███████      | 33/51 [00:09<00:05,  3.13it/s]

Number of matches 2359
Number of matches After Lowe's Ratio 590
Number of Robust matches 236


 67%|███████      | 34/51 [00:09<00:05,  3.27it/s]

Number of matches 2556
Number of matches After Lowe's Ratio 618
Number of Robust matches 264
```

```
 69%|████████    | 35/51 [00:09<00:04,  3.29it/s]
```

Number of matches 2370
Number of matches After Lowe's Ratio 627
Number of Robust matches 229

```
 71%|████████    | 36/51 [00:10<00:04,  3.46it/s]
```

Number of matches 2175
Number of matches After Lowe's Ratio 623
Number of Robust matches 289

```
 73%|████████▋   | 37/51 [00:10<00:03,  3.72it/s]
```

Number of matches 1943
Number of matches After Lowe's Ratio 490
Number of Robust matches 165

```
 76%|████████▊   | 39/51 [00:10<00:02,  4.34it/s]
```

Number of matches 1749
Number of matches After Lowe's Ratio 261
Number of Robust matches 132

Number of matches 1809
Number of matches After Lowe's Ratio 509
Number of Robust matches 235

```
 78%|█████████   | 40/51 [00:11<00:02,  4.58it/s]
```

Number of matches 1908
Number of matches After Lowe's Ratio 443
Number of Robust matches 211

Number of matches 1778
Number of matches After Lowe's Ratio 375

```
 82%|█████████▍  | 42/51 [00:11<00:01,  4.83it/s]
```

Number of Robust matches 165

Number of matches 2041
Number of matches After Lowe's Ratio 411
Number of Robust matches 173

```
 84%|█████████▋  | 43/51 [00:11<00:01,  4.73it/s]
```

Number of matches 2214
Number of matches After Lowe's Ratio 636
Number of Robust matches 291

```
 86%|█████████▋  | 44/51 [00:11<00:01,  4.65it/s]
```

Number of matches 2180

```
Number of matches After Lowe's Ratio 310
Number of Robust matches 137


 88%|████████▊  | 45/51 [00:12<00:01,  4.55it/s]

Number of matches 2265
Number of matches After Lowe's Ratio 287
Number of Robust matches 123


 90%|████████▉  | 46/51 [00:12<00:01,  4.29it/s]

Number of matches 2489
Number of matches After Lowe's Ratio 423
Number of Robust matches 121


 92%|█████████▏ | 47/51 [00:12<00:00,  4.11it/s]

Number of matches 2634
Number of matches After Lowe's Ratio 592
Number of Robust matches 220


 94%|█████████▍ | 48/51 [00:12<00:00,  3.90it/s]

Number of matches 2578
Number of matches After Lowe's Ratio 324
Number of Robust matches 105


 96%|█████████▌ | 49/51 [00:13<00:00,  3.81it/s]

Number of matches 2583
Number of matches After Lowe's Ratio 621
Number of Robust matches 202


  0%|           | 0/59 [00:00<?, ?it/s]

Number of matches 2358
Number of matches After Lowe's Ratio 76
Number of Robust matches 31


  2%|▏          | 1/59 [00:00<00:16,  3.60it/s]

Number of matches 2122
Number of matches After Lowe's Ratio 271
Number of Robust matches 103


  3%|▎          | 2/59 [00:00<00:15,  3.66it/s]

Number of matches 2642
Number of matches After Lowe's Ratio 267
Number of Robust matches 97


  5%|▌          | 3/59 [00:00<00:15,  3.56it/s]

Number of matches 2570
Number of matches After Lowe's Ratio 158
Number of Robust matches 57
```

```
  7%|█          | 4/59 [00:01<00:15,  3.44it/s]
```

Number of matches 2761
Number of matches After Lowe's Ratio 269
Number of Robust matches 83

```
  8%|█          | 5/59 [00:01<00:16,  3.26it/s]
```

Number of matches 2847
Number of matches After Lowe's Ratio 142
Number of Robust matches 39

```
 10%|█          | 6/59 [00:01<00:16,  3.20it/s]
```

Number of matches 2731
Number of matches After Lowe's Ratio 541
Number of Robust matches 185

```
 12%|█          | 7/59 [00:02<00:16,  3.15it/s]
```

Number of matches 3077
Number of matches After Lowe's Ratio 19
Number of Robust matches 6

```
 14%|█          | 8/59 [00:02<00:16,  3.05it/s]
```

Number of matches 2649
Number of matches After Lowe's Ratio 186
Number of Robust matches 32

```
 15%|█          | 9/59 [00:02<00:16,  3.10it/s]
```

Number of matches 2573
Number of matches After Lowe's Ratio 221
Number of Robust matches 47

```
 17%|██         | 10/59 [00:03<00:15,  3.16it/s]
```

Number of matches 2515
Number of matches After Lowe's Ratio 196
Number of Robust matches 69

```
 19%|██         | 11/59 [00:03<00:14,  3.26it/s]
```

Number of matches 2578
Number of matches After Lowe's Ratio 342
Number of Robust matches 146

```
 22%|██         | 13/59 [00:03<00:12,  3.78it/s]
```

Number of matches 1782
Number of matches After Lowe's Ratio 381
Number of Robust matches 172

Number of matches 1452
Number of matches After Lowe's Ratio 177

```
Number of Robust matches 108


 24%|██        | 14/59 [00:04<00:10,  4.16it/s]

Number of matches 2306
Number of matches After Lowe's Ratio 139
Number of Robust matches 67


 25%|██        | 15/59 [00:04<00:10,  4.20it/s]

Number of matches 1911
Number of matches After Lowe's Ratio 463
Number of Robust matches 232


 27%|██        | 16/59 [00:04<00:10,  4.22it/s]

Number of matches 2142
Number of matches After Lowe's Ratio 254
Number of Robust matches 139


 29%|██        | 17/59 [00:04<00:09,  4.24it/s]

Number of matches 2191
Number of matches After Lowe's Ratio 595
Number of Robust matches 350


 31%|███       | 18/59 [00:04<00:09,  4.18it/s]

Number of matches 2029
Number of matches After Lowe's Ratio 533
Number of Robust matches 271


 32%|███       | 19/59 [00:05<00:09,  4.19it/s]

Number of matches 2512
Number of matches After Lowe's Ratio 593
Number of Robust matches 332


 34%|███       | 20/59 [00:05<00:09,  3.99it/s]

Number of matches 2412
Number of matches After Lowe's Ratio 669
Number of Robust matches 341


 36%|███       | 21/59 [00:05<00:09,  3.91it/s]

Number of matches 2826
Number of matches After Lowe's Ratio 365
Number of Robust matches 168


 37%|███       | 22/59 [00:06<00:10,  3.62it/s]

Number of matches 2981
Number of matches After Lowe's Ratio 587
Number of Robust matches 281
```

```
 39%|███          | 23/59 [00:06<00:10,  3.34it/s]
```

Number of matches 3041
Number of matches After Lowe's Ratio 596
Number of Robust matches 206

```
 41%|███          | 24/59 [00:06<00:10,  3.23it/s]
```

Number of matches 3227
Number of matches After Lowe's Ratio 693
Number of Robust matches 269

```
 42%|████         | 25/59 [00:07<00:11,  3.09it/s]
```

Number of matches 3127
Number of matches After Lowe's Ratio 538
Number of Robust matches 191

```
 44%|████         | 26/59 [00:07<00:10,  3.05it/s]
```

Number of matches 3082
Number of matches After Lowe's Ratio 753
Number of Robust matches 278

```
 46%|████         | 27/59 [00:07<00:10,  3.02it/s]
```

Number of matches 2828
Number of matches After Lowe's Ratio 581
Number of Robust matches 195

```
 47%|█████        | 28/59 [00:08<00:10,  3.06it/s]
```

Number of matches 2804
Number of matches After Lowe's Ratio 746
Number of Robust matches 218

```
 49%|█████        | 29/59 [00:08<00:09,  3.05it/s]
```

Number of matches 3047
Number of matches After Lowe's Ratio 702
Number of Robust matches 199

```
 51%|█████        | 30/59 [00:08<00:09,  3.01it/s]
```

Number of matches 3292
Number of matches After Lowe's Ratio 389
Number of Robust matches 132

```
 53%|█████        | 31/59 [00:09<00:09,  2.98it/s]
```

Number of matches 2865
Number of matches After Lowe's Ratio 329
Number of Robust matches 122

```
 54%|██████       | 32/59 [00:09<00:09,  2.98it/s]
```

Number of matches 3522
Number of matches After Lowe's Ratio 127

```
Number of Robust matches 43


 56%|██████        | 33/59 [00:09<00:09,  2.76it/s]

Number of matches 3409
Number of matches After Lowe's Ratio 523
Number of Robust matches 129


 58%|███████       | 34/59 [00:10<00:09,  2.72it/s]

Number of matches 3648
Number of matches After Lowe's Ratio 10
Number of Robust matches 4


 59%|███████       | 35/59 [00:10<00:09,  2.61it/s]

Number of matches 3290
Number of matches After Lowe's Ratio 371
Number of Robust matches 98


 61%|███████       | 36/59 [00:11<00:08,  2.67it/s]

Number of matches 3162
Number of matches After Lowe's Ratio 412
Number of Robust matches 134


 63%|████████      | 37/59 [00:11<00:07,  2.79it/s]

Number of matches 2667
Number of matches After Lowe's Ratio 593
Number of Robust matches 196


 64%|████████      | 38/59 [00:11<00:07,  2.95it/s]

Number of matches 3045
Number of matches After Lowe's Ratio 331
Number of Robust matches 126


 66%|████████      | 39/59 [00:12<00:06,  2.93it/s]

Number of matches 2955
Number of matches After Lowe's Ratio 367
Number of Robust matches 104


 68%|████████      | 40/59 [00:12<00:06,  2.98it/s]

Number of matches 2928
Number of matches After Lowe's Ratio 497
Number of Robust matches 171


 69%|█████████     | 41/59 [00:12<00:05,  3.05it/s]

Number of matches 2889
Number of matches After Lowe's Ratio 869
Number of Robust matches 266
```

```
 71%|██████      | 42/59 [00:12<00:05,  3.03it/s]
```

Number of matches 2877
Number of matches After Lowe's Ratio 536
Number of Robust matches 171

```
 73%|███████     | 43/59 [00:13<00:05,  3.12it/s]
```

Number of matches 2724
Number of matches After Lowe's Ratio 68
Number of Robust matches 24

```
 75%|███████     | 44/59 [00:13<00:04,  3.20it/s]
```

Number of matches 2688
Number of matches After Lowe's Ratio 445
Number of Robust matches 154

```
 76%|███████     | 45/59 [00:13<00:04,  3.22it/s]
```

Number of matches 2695
Number of matches After Lowe's Ratio 307
Number of Robust matches 113

```
 78%|████████    | 46/59 [00:14<00:03,  3.33it/s]
```

Number of matches 2283
Number of matches After Lowe's Ratio 162
Number of Robust matches 85

```
 80%|████████    | 47/59 [00:14<00:03,  3.49it/s]
```

Number of matches 2330
Number of matches After Lowe's Ratio 349
Number of Robust matches 157

```
 81%|████████    | 48/59 [00:14<00:03,  3.64it/s]
```

Number of matches 2095
Number of matches After Lowe's Ratio 338
Number of Robust matches 154

```
 83%|████████    | 49/59 [00:14<00:02,  3.82it/s]
```

Number of matches 2164
Number of matches After Lowe's Ratio 653
Number of Robust matches 276

```
 85%|█████████   | 50/59 [00:15<00:02,  3.93it/s]
```

Number of matches 2280
Number of matches After Lowe's Ratio 368
Number of Robust matches 153

```
 86%|█████████   | 51/59 [00:15<00:02,  3.95it/s]
```

Number of matches 2267
Number of matches After Lowe's Ratio 653

```
Number of matches After Lowe's Ratio 653
Number of Robust matches 231
```

```
 90%|████████  | 53/59 [00:15<00:01,  4.39it/s]
```

```
Number of matches 1729
Number of matches After Lowe's Ratio 259
Number of Robust matches 96
```

```
Number of matches 1584
Number of matches After Lowe's Ratio 396
Number of Robust matches 135
```

```
 93%|█████████ | 55/59 [00:16<00:00,  5.16it/s]
```

```
Number of matches 1530
Number of matches After Lowe's Ratio 217
Number of Robust matches 63
```

```
Number of matches 1591
Number of matches After Lowe's Ratio 417
Number of Robust matches 181
```

```
 95%|█████████ | 56/59 [00:16<00:00,  5.15it/s]
```

```
Number of matches 1992
Number of matches After Lowe's Ratio 280
Number of Robust matches 93
```

```
 97%|█████████ | 57/59 [00:16<00:00,  4.89it/s]
```

```
Number of matches 2134
Number of matches After Lowe's Ratio 433
Number of Robust matches 148
```

```
 98%|█████████ | 58/59 [00:16<00:00,  4.60it/s]
```

```
Number of matches 2368
Number of matches After Lowe's Ratio 468
Number of Robust matches 162
```

In [32]:

```python
xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_mser,H_right_mser)
```

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

In [33]:

```python
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_mser,xmax,xmin,
ymax,ymin,t,h,w,Ht)
```

```
step31:Done
```

In [34]:

```
warp_imgs_all_mser = final_step_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_
right_mser,xmax,xmin,ymax,ymin,t,h,w,Ht)
```

step32:Done

In [35]:

```
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')
```

Out[35]:

Text(0.5, 1.0, '120-Images Mosaic-MSER')
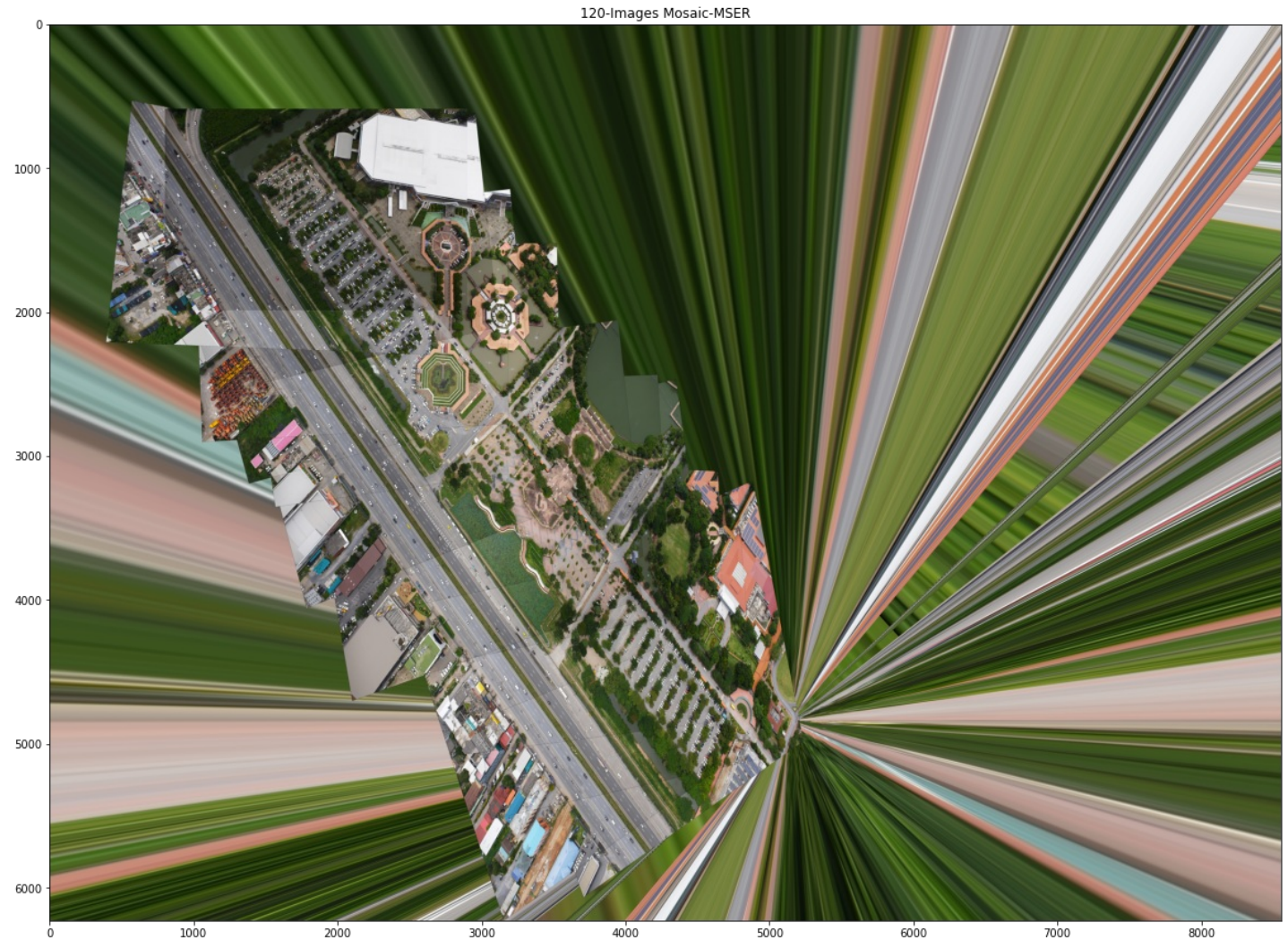
For Agast 110 images

In [ ]:

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

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


for imgs in tqdm(images_left_bgr_no_enhance):
    kpt = agast.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_left_agast.append(kpt)
```

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


for imgs in tqdm(images_right_bgr_no_enhance):
    kpt = agast.detect(imgs,None)
    kpt,descrip = sift.compute(imgs, kpt)
    keypoints_all_right_agast.append(kpt)
    descriptors_all_right_agast.append(descrip)
    points_all_right_agast.append(np.asarray([[p.pt[0], p.pt[1]] for p in kpt]))
```
```
100%|██████████| 51/51 [06:52<00:00,  8.08s/it]
 46%|████      | 27/59 [03:41<05:01,  9.41s/it]
```

In [ ]:

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

In [ ]:

```
H_left_agast = []
H_right_agast = []

num_matches_agast = []
num_good_matches_agast = []

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

    H_a,matches,gd_matches = get_Hmatrix(images_left_bgr[j:j+2][::-1],keypoints_all_left
_agast[j:j+2][::-1],points_all_left_agast[j:j+2][::-1],descriptors_all_left_agast[j:j+2]
[::-1])
    H_left_agast.append(H_a)
    num_matches_agast.append(matches)
    num_good_matches_agast.append(gd_matches)

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

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_agast[j:j+2][::-1],points_all_right_agast[j:j+2][::-1],descriptors_all_right_agast[j:
j+2][::-1])
    H_right_agast.append(H_a)
    num_matches_agast.append(matches)
    num_good_matches_agast.append(gd_matches)
```

In [ ]:

```
omax,omin,umax,umin,T,H,W,HT = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_agast,H_right_agast)
```

In [ ]:

```
warp_img = final_steps_left_union(images_left_bgr_no_enhance,H_left_agast,omax,omin,umax,
umin,T,H,W,HT)
```

In [ ]:

```
warp_imgs_all_agast = final_step_right_union(warp_img,images_right_bgr_no_enhance,H_right
_agast,omax,omin,umax,umin,T,H,W,HT)
```

In [ ]:

```
fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_agast , cv2.COLOR_BGR2RGB))
ax.set_title('110-Images Mosaic-AGAST')
```

For Fast 110 images

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

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

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

```
100%|████████| 51/51 [06:00<00:00,  7.06s/it]
100%|████████| 59/59 [06:58<00:00,  7.09s/it]
```

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

```python
H_left_fast = []
H_right_fast = []

num_matches_fast = []
num_good_matches_fast = []

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

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

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

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

```python
omax,omin,ymax,ymin,T,H,W,HT = warpnImages(images_left_bgr_no_enhance, images_right_bgr
```

```
omax,omin,umax,umin,T,H,W,HT = warpImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_fast,H_right_fast)
```

In [ ]:

```
warp_img = final_steps_left_union(images_left_bgr_no_enhance,H_left_fast,omax,omin,umax,u
min,T,H,W,HT)
```

In [ ]:

```
warp_imgs_all_fast = final_step_right_union(warp_img,images_right_bgr_no_enhance,H_right_
fast,omax,omin,umax,umin,T,H,W,HT)
```

In [ ]:

```
fig,ax =plt.subplots()
fig.set_size_inches(20,20)
ax.imshow(cv2.cvtColor(warp_imgs_all_fast , cv2.COLOR_BGR2RGB))
ax.set_title('110-Images Mosaic-FAST')
```

For Gftt 110 images

In [11]:

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

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

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

```
100%|████████| 51/51 [00:10<00:00,  4.81it/s]
100%|████████| 59/59 [00:12<00:00,  4.72it/s]
```

In [17]:

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

```
100%|████████| 110/110 [00:00<00:00, 29827.61it/s]
```

In [22]:

```
H_left_gftt = []
H_right_gftt = []

num_matches_gftt = []
num_good_matches_gftt = []

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

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

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

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

  6%|▊ | 3/51 [00:00<00:04, 10.32it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 280
Number of Robust matches 230



Number of matches 1000
Number of matches After Lowe's Ratio 75
Number of Robust matches 27



Number of matches 1000
Number of matches After Lowe's Ratio 166
Number of Robust matches 106
```

 10%|█ | 5/51 [00:00<00:04, 10.70it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 235
Number of Robust matches 198



Number of matches 1000
Number of matches After Lowe's Ratio 317
Number of Robust matches 254



Number of matches 1000
Number of matches After Lowe's Ratio 316
Number of Robust matches 261
```

 18%|██ | 9/51 [00:00<00:03, 11.02it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 352
Number of Robust matches 284



Number of matches 1000
Number of matches After Lowe's Ratio 381
Number of Robust matches 275



Number of matches 1000
```

```
Number of matches After Lowe's Ratio 420
Number of Robust matches 318


 22%|██        | 11/51 [00:00<00:03, 11.32it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 323
Number of Robust matches 224


Number of matches 1000
Number of matches After Lowe's Ratio 190
Number of Robust matches 115


Number of matches 1000
Number of matches After Lowe's Ratio 358
Number of Robust matches 261


 29%|███       | 15/51 [00:01<00:03, 11.33it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 192
Number of Robust matches 132


Number of matches 1000
Number of matches After Lowe's Ratio 354
Number of Robust matches 276


Number of matches 1000
Number of matches After Lowe's Ratio 14
Number of Robust matches 5


 33%|███       | 17/51 [00:01<00:02, 11.40it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 53
Number of Robust matches 35


Number of matches 1000
Number of matches After Lowe's Ratio 333
Number of Robust matches 274


Number of matches 1000
Number of matches After Lowe's Ratio 71
Number of Robust matches 30


 41%|████      | 21/51 [00:01<00:02, 11.23it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 50
Number of Robust matches 21


Number of matches 1000
```

```
Number of matches After Lowe's Ratio 242
Number of Robust matches 159


Number of matches 1000
Number of matches After Lowe's Ratio 133
Number of Robust matches 88
```

45%|███████ | 23/51 [00:02<00:02, 10.71it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 30
Number of Robust matches 6


Number of matches 1000
Number of matches After Lowe's Ratio 368
Number of Robust matches 185
```

49%|███████ | 25/51 [00:02<00:02, 10.98it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 395
Number of Robust matches 210


Number of matches 1000
Number of matches After Lowe's Ratio 326
Number of Robust matches 197


Number of matches 1000
Number of matches After Lowe's Ratio 345
Number of Robust matches 192
```

53%|████████ | 27/51 [00:02<00:02, 10.76it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 333
Number of Robust matches 136


Number of matches 1000
Number of matches After Lowe's Ratio 312
Number of Robust matches 142


Number of matches 1000
Number of matches After Lowe's Ratio 267
```

61%|█████████ | 31/51 [00:02<00:01, 10.77it/s]

```
Number of Robust matches 141


Number of matches 1000
Number of matches After Lowe's Ratio 371
Number of Robust matches 277
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 399
Number of Robust matches 324
```

 65%|███████ | 33/51 [00:02<00:01, 10.96it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 353
Number of Robust matches 294
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 441
Number of Robust matches 357
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 375
Number of Robust matches 294
```

 73%|████████ | 37/51 [00:03<00:01, 11.27it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 392
Number of Robust matches 301
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 358
Number of Robust matches 229
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 322
Number of Robust matches 188
```

 76%|████████ | 39/51 [00:03<00:01, 11.03it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 296
Number of Robust matches 176
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 490
Number of Robust matches 404
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 454
Number of Robust matches 338
```

 84%|█████████ | 43/51 [00:03<00:00, 11.44it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 292
Number of Robust matches 195
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 266
Number of Robust matches 182


Number of matches 1000
Number of matches After Lowe's Ratio 369
Number of Robust matches 253
```

 88%|██████████ | 45/51 [00:04<00:00, 11.58it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 207
Number of Robust matches 148


Number of matches 1000
Number of matches After Lowe's Ratio 239
Number of Robust matches 187


Number of matches 1000
Number of matches After Lowe's Ratio 284
Number of Robust matches 190
```

 96%|███████████ | 49/51 [00:04<00:00, 11.57it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 395
Number of Robust matches 278


Number of matches 1000
Number of matches After Lowe's Ratio 218
Number of Robust matches 105


Number of matches 1000
Number of matches After Lowe's Ratio 354
Number of Robust matches 162
```

 96%|███████████ | 49/51 [00:04<00:00, 10.92it/s]
  0%| | 0/59 [00:00<?, ?it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 96
Number of Robust matches 24


Number of matches 1000
Number of matches After Lowe's Ratio 208
Number of Robust matches 135
```

  5%|█ | 3/59 [00:00<00:06, 8.92it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 193
Number of Robust matches 123
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 150
Number of Robust matches 79


  8%|█         | 5/59 [00:00<00:05,  9.56it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 212
Number of Robust matches 106



Number of matches 1000
Number of matches After Lowe's Ratio 163
Number of Robust matches 90



Number of matches 1000
Number of matches After Lowe's Ratio 296
Number of Robust matches 165


 14%|█         | 8/59 [00:00<00:05,  9.52it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 41
Number of Robust matches 8



Number of matches 1000
Number of matches After Lowe's Ratio 88
Number of Robust matches 23


 19%|██        | 11/59 [00:01<00:04, 10.02it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 173
Number of Robust matches 78



Number of matches 1000
Number of matches After Lowe's Ratio 199
Number of Robust matches 86



Number of matches 1000
Number of matches After Lowe's Ratio 368
Number of Robust matches 280


 22%|██        | 13/59 [00:01<00:04, 10.35it/s]

Number of matches 1000
Number of matches After Lowe's Ratio 387
Number of Robust matches 325



Number of matches 1000
Number of matches After Lowe's Ratio 252
Number of Robust matches 200
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 109
Number of Robust matches 57
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 375
Number of Robust matches 260
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 159
Number of Robust matches 111
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 461
Number of Robust matches 426
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 451
Number of Robust matches 388
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 389
Number of Robust matches 267
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 367
Number of Robust matches 265
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 225
Number of Robust matches 160
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 360
Number of Robust matches 265
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 377
Number of Robust matches 280
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 371
Number of Robust matches 297
```

```
Number of matches 1000
Number of matches After Lowe's Ratio 310
Number of Robust matches 230


Number of matches 1000
Number of matches After Lowe's Ratio 367
Number of Robust matches 255
```

49%|████████ | 29/59 [00:02<00:02, 11.14it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 329
Number of Robust matches 221


Number of matches 1000
Number of matches After Lowe's Ratio 371
Number of Robust matches 184


Number of matches 1000
Number of matches After Lowe's Ratio 355
Number of Robust matches 199
```

53%|████████ | 31/59 [00:02<00:02, 11.26it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 268
Number of Robust matches 161


Number of matches 1000
Number of matches After Lowe's Ratio 226
Number of Robust matches 137


Number of matches 1000
Number of matches After Lowe's Ratio 60
Number of Robust matches 23
```

56%|████████ | 33/59 [00:03<00:02, 11.44it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 154
Number of Robust matches 91


Number of matches 1000
Number of matches After Lowe's Ratio 19
Number of Robust matches 5


Number of matches 1000
Number of matches After Lowe's Ratio 133
```

63%|████████ | 37/59 [00:03<00:01, 11.28it/s]

```
Number of Robust matches 56


Number of matches 1000
Number of matches After Lowe's Ratio 291
Number of Robust matches 148


Number of matches 1000
Number of matches After Lowe's Ratio 355
Number of Robust matches 191
```

 66%|███████ | 39/59 [00:03<00:01, 11.32it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 262
Number of Robust matches 132


Number of matches 1000
Number of matches After Lowe's Ratio 284
Number of Robust matches 138


Number of matches 1000
Number of matches After Lowe's Ratio 243
Number of Robust matches 67
```

 73%|████████ | 43/59 [00:03<00:01, 11.06it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 389
Number of Robust matches 188


Number of matches 1000
Number of matches After Lowe's Ratio 216
Number of Robust matches 120


Number of matches 1000
Number of matches After Lowe's Ratio 85
Number of Robust matches 38
```

 76%|████████ | 45/59 [00:04<00:01, 10.90it/s]

```
Number of matches 1000
Number of matches After Lowe's Ratio 215
Number of Robust matches 101


Number of matches 1000
Number of matches After Lowe's Ratio 168
Number of Robust matches 92


Number of matches 1000
Number of matches After Lowe's Ratio 238
Number of Robust matches 194
```

```
 83%|████████   | 49/59 [00:04<00:00, 11.01it/s]
```

Number of matches 1000
Number of matches After Lowe's Ratio 373
Number of Robust matches 340

Number of matches 1000
Number of matches After Lowe's Ratio 345
Number of Robust matches 284

Number of matches 1000
Number of matches After Lowe's Ratio 536
Number of Robust matches 445

```
 86%|████████   | 51/59 [00:04<00:00, 11.19it/s]
```

Number of matches 1000
Number of matches After Lowe's Ratio 272
Number of Robust matches 207

Number of matches 1000
Number of matches After Lowe's Ratio 471
Number of Robust matches 360

Number of matches 1000
Number of matches After Lowe's Ratio 197
Number of Robust matches 138

```
 93%|█████████  | 55/59 [00:05<00:00, 10.85it/s]
```

Number of matches 1000
Number of matches After Lowe's Ratio 342
Number of Robust matches 250

Number of matches 1000
Number of matches After Lowe's Ratio 317
Number of Robust matches 238

Number of matches 1000
Number of matches After Lowe's Ratio 472
Number of Robust matches 347

```
 97%|█████████  | 57/59 [00:05<00:00, 10.65it/s]
```

Number of matches 1000
Number of matches After Lowe's Ratio 333
Number of Robust matches 280

Number of matches 1000
Number of matches After Lowe's Ratio 446

Number of Robust matches 363

Number of matches 1000
Number of matches After Lowe's Ratio 401
Number of Robust matches 316

In [24]:

```
omax,omin,umax,umin,T,H,W,HT = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_gftt,H_right_gftt)
```

Step1:Done
Step2:Done

In [25]:

```
warp_img = final_steps_left_union(images_left_bgr_no_enhance,H_left_gftt,omax,omin,umax,u
min,T,H,W,HT)
```

step31:Done

In [26]:

```
warp_imgs_all_gftt = final_step_right_union(warp_img,images_right_bgr_no_enhance,H_right_
gftt,omax,omin,umax,umin,T,H,W,HT)
```

step32:Done

In [27]:

```
plt.figure(figsize=(20,20))
plt.imshow(warp_imgs_all_gftt)
plt.title(' Mosaic using Gftt Image')
```

Out[27]:

Text(0.5, 1.0, ' Mosaic using Gftt Image')
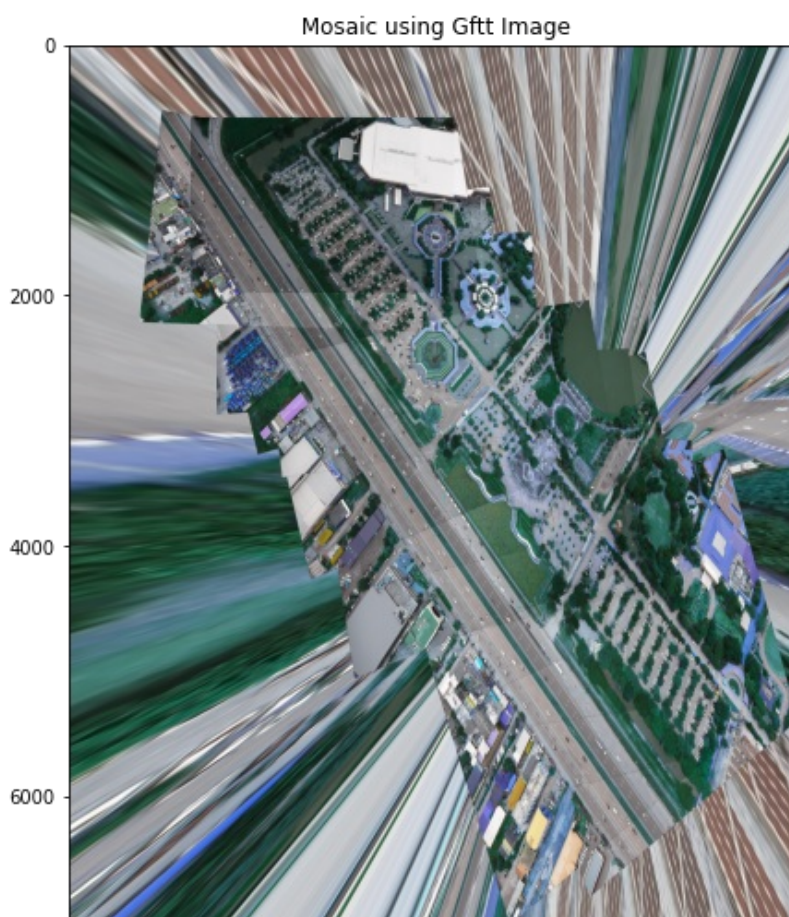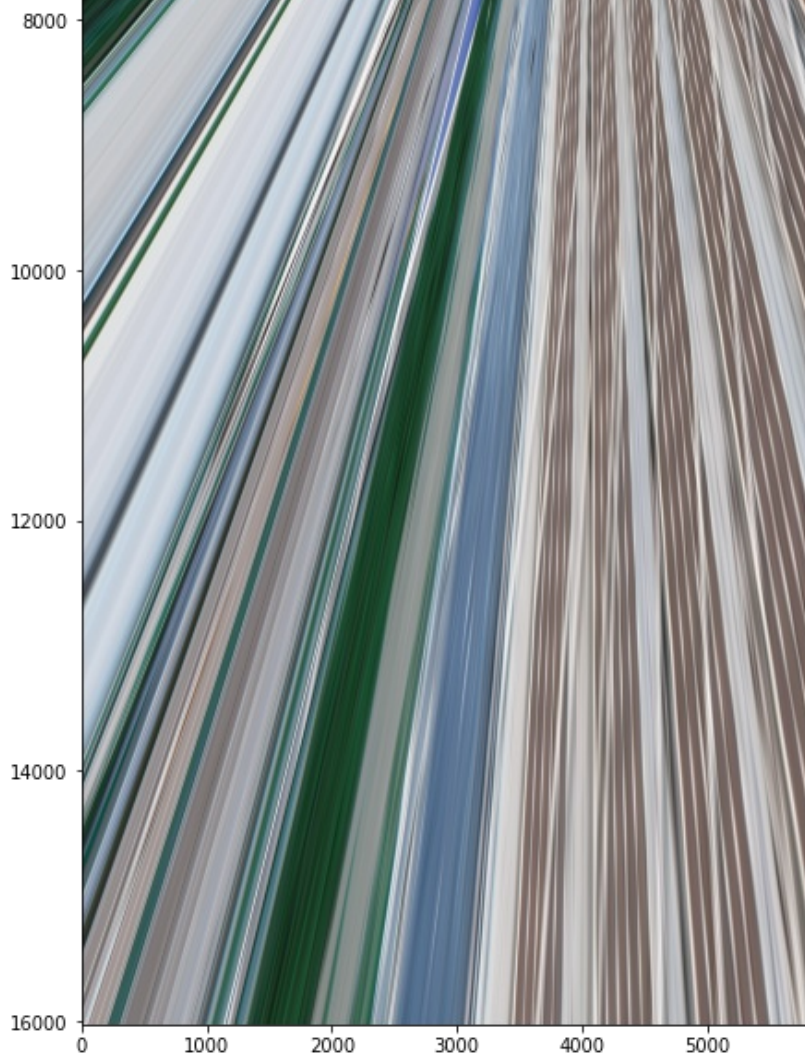
For Kaze 110 images

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

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

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

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

```
100%|██████████| 51/51 [06:11<00:00,  7.28s/it]
100%|██████████| 59/59 [06:59<00:00,  7.10s/it]
```

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

100%|██████████| 110/110 [00:00<00:00, 397735.72it/s]

In [24]:

```
H_left_kaze = []
H_right_kaze = []

num_matches_kaze = []
num_good_matches_kaze = []

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

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

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

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

  2%|▏ | 1/51 [00:01<01:12, 1.46s/it]

```
Number of matches 22285
Number of matches After Lowe's Ratio 5336
Number of Robust matches 3611
```

  4%|▏ | 2/51 [00:03<01:16, 1.55s/it]

```
Number of matches 22018
Number of matches After Lowe's Ratio 6512
Number of Robust matches 4800
```

  6%|▎ | 3/51 [00:05<01:20, 1.67s/it]

```
Number of matches 24330
Number of matches After Lowe's Ratio 6243
Number of Robust matches 4128
```

  8%|▍ | 4/51 [00:07<01:27, 1.86s/it]

```
Number of matches 24904
Number of matches After Lowe's Ratio 9111
Number of Robust matches 6161
```

 10%|▌ | 5/51 [00:09<01:30, 1.97s/it]

```
Number of matches 23410
Number of matches After Lowe's Ratio 6915
Number of Robust matches 5282
```

```
 12%|█           | 6/51 [00:11<01:32,  2.05s/it]
```

Number of matches 21871
Number of matches After Lowe's Ratio 7173
Number of Robust matches 5237

```
 14%|█           | 7/51 [00:13<01:29,  2.03s/it]
```

Number of matches 21387
Number of matches After Lowe's Ratio 6390
Number of Robust matches 5207

```
 16%|█▌          | 8/51 [00:15<01:22,  1.91s/it]
```

Number of matches 21095
Number of matches After Lowe's Ratio 7119
Number of Robust matches 5557

```
 18%|█▌          | 9/51 [00:17<01:17,  1.86s/it]
```

Number of matches 21423
Number of matches After Lowe's Ratio 8038
Number of Robust matches 5355

```
 20%|██          | 10/51 [00:19<01:15,  1.85s/it]
```

Number of matches 20665
Number of matches After Lowe's Ratio 6637
Number of Robust matches 4556

```
 22%|██          | 11/51 [00:20<01:10,  1.77s/it]
```

Number of matches 21776
Number of matches After Lowe's Ratio 5891
Number of Robust matches 3285

```
 24%|██▌         | 12/51 [00:22<01:11,  1.84s/it]
```

Number of matches 21075
Number of matches After Lowe's Ratio 5816
Number of Robust matches 4016

```
 25%|██▌         | 13/51 [00:24<01:10,  1.85s/it]
```

Number of matches 22361
Number of matches After Lowe's Ratio 5750
Number of Robust matches 3714

```
 27%|██▌         | 14/51 [00:26<01:09,  1.89s/it]
```

Number of matches 21739
Number of matches After Lowe's Ratio 4923
Number of Robust matches 3137

```
 29%|███         | 15/51 [00:28<01:10,  1.96s/it]
```

```
Number of matches 24424
Number of matches After Lowe's Ratio 4574
Number of Robust matches 2599


 31%|███        | 16/51 [00:30<01:10,  2.01s/it]

Number of matches 21469
Number of matches After Lowe's Ratio 4705
Number of Robust matches 2409


 33%|███        | 17/51 [00:32<01:07,  1.99s/it]

Number of matches 22552
Number of matches After Lowe's Ratio 4912
Number of Robust matches 2800


 35%|███        | 18/51 [00:34<01:05,  1.99s/it]

Number of matches 21879
Number of matches After Lowe's Ratio 4774
Number of Robust matches 1850


 37%|███        | 19/51 [00:36<01:04,  2.03s/it]

Number of matches 25013
Number of matches After Lowe's Ratio 3107
Number of Robust matches 1393


 39%|███        | 20/51 [00:39<01:04,  2.08s/it]

Number of matches 24466
Number of matches After Lowe's Ratio 4452
Number of Robust matches 1845


 41%|████       | 21/51 [00:41<01:02,  2.07s/it]

Number of matches 24798
Number of matches After Lowe's Ratio 2433
Number of Robust matches 877


 43%|████       | 22/51 [00:43<00:59,  2.06s/it]

Number of matches 21670
Number of matches After Lowe's Ratio 1116
Number of Robust matches 326


 45%|████       | 23/51 [00:45<00:56,  2.01s/it]

Number of matches 21083
Number of matches After Lowe's Ratio 4284
Number of Robust matches 2115


 47%|████       | 24/51 [00:46<00:51,  1.91s/it]

Number of matches 19041
Number of matches After Lowe's Ratio 4717
Number of Robust matches 2715
```

```
Number of Robust matches 2419
```

```
 49%|███████        | 25/51 [00:48<00:46,  1.79s/it]
```

```
Number of matches 21135
Number of matches After Lowe's Ratio 4231
Number of Robust matches 2503
```

```
 51%|███████        | 26/51 [00:50<00:45,  1.83s/it]
```

```
Number of matches 25378
Number of matches After Lowe's Ratio 5638
Number of Robust matches 2373
```

```
 53%|███████        | 27/51 [00:52<00:48,  2.03s/it]
```

```
Number of matches 28928
Number of matches After Lowe's Ratio 5182
Number of Robust matches 2165
```

```
 55%|███████        | 28/51 [00:55<00:52,  2.26s/it]
```

```
Number of matches 31135
Number of matches After Lowe's Ratio 6999
Number of Robust matches 2624
```

```
 57%|███████        | 29/51 [00:58<00:54,  2.46s/it]
```

```
Number of matches 28082
Number of matches After Lowe's Ratio 6745
Number of Robust matches 3174
```

```
 59%|███████        | 30/51 [01:00<00:51,  2.46s/it]
```

```
Number of matches 24578
Number of matches After Lowe's Ratio 6467
Number of Robust matches 3219
```

```
 61%|███████        | 31/51 [01:03<00:47,  2.38s/it]
```

```
Number of matches 22760
Number of matches After Lowe's Ratio 6570
Number of Robust matches 4112
```

```
 63%|███████        | 32/51 [01:04<00:42,  2.24s/it]
```

```
Number of matches 21201
Number of matches After Lowe's Ratio 6219
Number of Robust matches 3810
```

```
 65%|███████        | 33/51 [01:06<00:37,  2.10s/it]
```

```
Number of matches 21619
Number of matches After Lowe's Ratio 7188
Number of Robust matches 5285
```

```
 67%|███████        | 34/51 [01:08<00:34,  2.03s/it]
```

```
 67%|████████      | 34/51 [01:08<00:34,  2.02s/it]

Number of matches 23323
Number of matches After Lowe's Ratio 6381
Number of Robust matches 4220


 69%|████████      | 35/51 [01:10<00:31,  2.00s/it]

Number of matches 24274
Number of matches After Lowe's Ratio 7486
Number of Robust matches 4201


 71%|████████      | 36/51 [01:12<00:30,  2.00s/it]

Number of matches 23964
Number of matches After Lowe's Ratio 7815
Number of Robust matches 4805


 73%|████████      | 37/51 [01:14<00:28,  2.06s/it]

Number of matches 23881
Number of matches After Lowe's Ratio 7500
Number of Robust matches 4172


 75%|████████      | 38/51 [01:16<00:26,  2.06s/it]

Number of matches 22006
Number of matches After Lowe's Ratio 4718
Number of Robust matches 3006


 76%|████████      | 39/51 [01:18<00:23,  2.00s/it]

Number of matches 21045
Number of matches After Lowe's Ratio 7925
Number of Robust matches 4860


 78%|████████      | 40/51 [01:20<00:21,  1.98s/it]

Number of matches 21574
Number of matches After Lowe's Ratio 7709
Number of Robust matches 5118


 80%|████████      | 41/51 [01:22<00:18,  1.89s/it]

Number of matches 19699
Number of matches After Lowe's Ratio 4771
Number of Robust matches 3305


 82%|████████      | 42/51 [01:23<00:16,  1.80s/it]

Number of matches 20924
Number of matches After Lowe's Ratio 4994
Number of Robust matches 3275


 84%|████████      | 43/51 [01:25<00:14,  1.80s/it]

Number of matches 21133
Number of matches After Lowe's Ratio 6833
```

```
Number of Robust matches 5120


 86%|████████   | 44/51 [01:27<00:12,  1.77s/it]

Number of matches 21286
Number of matches After Lowe's Ratio 4964
Number of Robust matches 3532


 88%|████████   | 45/51 [01:29<00:10,  1.75s/it]

Number of matches 20795
Number of matches After Lowe's Ratio 5592
Number of Robust matches 3791


 90%|████████   | 46/51 [01:30<00:08,  1.72s/it]

Number of matches 20754
Number of matches After Lowe's Ratio 4818
Number of Robust matches 2421


 92%|████████   | 47/51 [01:32<00:06,  1.73s/it]

Number of matches 21466
Number of matches After Lowe's Ratio 6504
Number of Robust matches 3389


 94%|████████   | 48/51 [01:34<00:05,  1.72s/it]

Number of matches 22210
Number of matches After Lowe's Ratio 4469
Number of Robust matches 1819


 96%|████████   | 49/51 [01:35<00:03,  1.76s/it]

Number of matches 22050
Number of matches After Lowe's Ratio 5961
Number of Robust matches 2523


  0%|          | 0/59 [00:00<?, ?it/s]

Number of matches 19110
Number of matches After Lowe's Ratio 1838
Number of Robust matches 542


  2%|          | 1/59 [00:01<01:50,  1.91s/it]

Number of matches 17408
Number of matches After Lowe's Ratio 4560
Number of Robust matches 2532


  3%|          | 2/59 [00:03<01:40,  1.77s/it]

Number of matches 22778
Number of matches After Lowe's Ratio 3209
Number of Robust matches 1821
```

```
  5%|█          | 3/59 [00:05<01:41,  1.81s/it]

Number of matches 20426
Number of matches After Lowe's Ratio 5970
Number of Robust matches 3397


  7%|█          | 4/59 [00:06<01:38,  1.79s/it]

Number of matches 20021
Number of matches After Lowe's Ratio 5255
Number of Robust matches 2909


  8%|█          | 5/59 [00:08<01:33,  1.73s/it]

Number of matches 19469
Number of matches After Lowe's Ratio 5546
Number of Robust matches 3050


 10%|█          | 6/59 [00:10<01:29,  1.69s/it]

Number of matches 20398
Number of matches After Lowe's Ratio 5001
Number of Robust matches 2573


 12%|█          | 7/59 [00:11<01:28,  1.70s/it]

Number of matches 23066
Number of matches After Lowe's Ratio 681
Number of Robust matches 173


 14%|█          | 8/59 [00:13<01:30,  1.77s/it]

Number of matches 17737
Number of matches After Lowe's Ratio 1983
Number of Robust matches 763


 15%|█          | 9/59 [00:15<01:22,  1.65s/it]

Number of matches 17684
Number of matches After Lowe's Ratio 2262
Number of Robust matches 999


 17%|█          | 10/59 [00:16<01:17,  1.57s/it]

Number of matches 19340
Number of matches After Lowe's Ratio 2961
Number of Robust matches 1471


 19%|█          | 11/59 [00:18<01:15,  1.58s/it]

Number of matches 22253
Number of matches After Lowe's Ratio 5347
Number of Robust matches 3694


 20%|██         | 12/59 [00:20<01:18,  1.66s/it]

Number of matches 19990
Number of matches After Lowe's Ratio 5607
```

```
Number of Robust matches 3788


 22%|██          | 13/59 [00:21<01:14,  1.61s/it]

Number of matches 17969
Number of matches After Lowe's Ratio 2771
Number of Robust matches 1697


 24%|██          | 14/59 [00:22<01:09,  1.55s/it]

Number of matches 21377
Number of matches After Lowe's Ratio 1791
Number of Robust matches 1019


 25%|██          | 15/59 [00:24<01:09,  1.57s/it]

Number of matches 18219
Number of matches After Lowe's Ratio 4653
Number of Robust matches 3357


 27%|██          | 16/59 [00:26<01:07,  1.57s/it]

Number of matches 23113
Number of matches After Lowe's Ratio 3603
Number of Robust matches 2585


 29%|██          | 17/59 [00:28<01:09,  1.65s/it]

Number of matches 23306
Number of matches After Lowe's Ratio 8479
Number of Robust matches 5727


 31%|███         | 18/59 [00:29<01:10,  1.73s/it]

Number of matches 22231
Number of matches After Lowe's Ratio 8812
Number of Robust matches 7452


 32%|███         | 19/59 [00:31<01:12,  1.81s/it]

Number of matches 20707
Number of matches After Lowe's Ratio 6875
Number of Robust matches 5249


 34%|███         | 20/59 [00:33<01:09,  1.79s/it]

Number of matches 21002
Number of matches After Lowe's Ratio 7024
Number of Robust matches 5844


 36%|███         | 21/59 [00:35<01:08,  1.81s/it]

Number of matches 22557
Number of matches After Lowe's Ratio 5656
Number of Robust matches 3641
```

```
 37%|██████       | 22/59 [00:37<01:09,  1.88s/it]
```

Number of matches 22744
Number of matches After Lowe's Ratio 6967
Number of Robust matches 4581

```
 39%|██████       | 23/59 [00:39<01:09,  1.93s/it]
```

Number of matches 23731
Number of matches After Lowe's Ratio 6293
Number of Robust matches 4175

```
 41%|███████      | 24/59 [00:41<01:10,  2.02s/it]
```

Number of matches 25368
Number of matches After Lowe's Ratio 7109
Number of Robust matches 4203

```
 42%|███████      | 25/59 [00:44<01:11,  2.10s/it]
```

Number of matches 25661
Number of matches After Lowe's Ratio 7457
Number of Robust matches 3628

```
 44%|███████      | 26/59 [00:46<01:11,  2.17s/it]
```

Number of matches 24425
Number of matches After Lowe's Ratio 7855
Number of Robust matches 3642

```
 46%|████████     | 27/59 [00:48<01:10,  2.19s/it]
```

Number of matches 22841
Number of matches After Lowe's Ratio 6343
Number of Robust matches 2558

```
 47%|████████     | 28/59 [00:50<01:05,  2.13s/it]
```

Number of matches 22352
Number of matches After Lowe's Ratio 7262
Number of Robust matches 3080

```
 49%|████████     | 29/59 [00:52<01:02,  2.07s/it]
```

Number of matches 21771
Number of matches After Lowe's Ratio 5814
Number of Robust matches 2302

```
 51%|█████████    | 30/59 [00:54<00:59,  2.04s/it]
```

Number of matches 20959
Number of matches After Lowe's Ratio 5551
Number of Robust matches 2183

```
 53%|█████████    | 31/59 [00:56<00:54,  1.95s/it]
```

Number of matches 20882
Number of matches After Lowe's Ratio 4413

```
Number of matches After Lowe's Ratio 4413
Number of Robust matches 2286


 54%|██████      | 32/59 [00:58<00:53,  1.97s/it]

Number of matches 28555
Number of matches After Lowe's Ratio 2064
Number of Robust matches 909


 56%|██████      | 33/59 [01:00<00:56,  2.16s/it]

Number of matches 26455
Number of matches After Lowe's Ratio 4181
Number of Robust matches 1630


 58%|██████      | 34/59 [01:03<00:57,  2.31s/it]

Number of matches 31041
Number of matches After Lowe's Ratio 523
Number of Robust matches 49


 59%|███████     | 35/59 [01:06<00:58,  2.45s/it]

Number of matches 25532
Number of matches After Lowe's Ratio 3374
Number of Robust matches 1281


 61%|███████     | 36/59 [01:08<00:54,  2.36s/it]

Number of matches 23237
Number of matches After Lowe's Ratio 5682
Number of Robust matches 2426


 63%|███████     | 37/59 [01:10<00:49,  2.26s/it]

Number of matches 21219
Number of matches After Lowe's Ratio 4896
Number of Robust matches 2136


 64%|███████     | 38/59 [01:12<00:44,  2.10s/it]

Number of matches 20480
Number of matches After Lowe's Ratio 4407
Number of Robust matches 1990


 66%|███████     | 39/59 [01:13<00:39,  1.97s/it]

Number of matches 22293
Number of matches After Lowe's Ratio 4745
Number of Robust matches 1757


 68%|████████    | 40/59 [01:15<00:36,  1.94s/it]

Number of matches 21755
Number of matches After Lowe's Ratio 4650
Number of Robust matches 1760
```

```
 69%|███████     | 41/59 [01:17<00:33,  1.88s/it]

Number of matches 22020
Number of matches After Lowe's Ratio 7625
Number of Robust matches 3012


 71%|███████     | 42/59 [01:19<00:32,  1.89s/it]

Number of matches 23245
Number of matches After Lowe's Ratio 4255
Number of Robust matches 1991


 73%|███████     | 43/59 [01:21<00:31,  1.96s/it]

Number of matches 22554
Number of matches After Lowe's Ratio 7193
Number of Robust matches 4267


 75%|████████    | 44/59 [01:23<00:28,  1.93s/it]

Number of matches 21359
Number of matches After Lowe's Ratio 5425
Number of Robust matches 2457


 76%|████████    | 45/59 [01:25<00:26,  1.87s/it]

Number of matches 20079
Number of matches After Lowe's Ratio 4546
Number of Robust matches 2397


 78%|████████    | 46/59 [01:26<00:23,  1.80s/it]

Number of matches 20334
Number of matches After Lowe's Ratio 3744
Number of Robust matches 2455


 80%|████████    | 47/59 [01:28<00:21,  1.78s/it]

Number of matches 20129
Number of matches After Lowe's Ratio 4645
Number of Robust matches 3002


 81%|████████    | 48/59 [01:30<00:19,  1.74s/it]

Number of matches 19798
Number of matches After Lowe's Ratio 4583
Number of Robust matches 2789


 83%|████████    | 49/59 [01:31<00:17,  1.71s/it]

Number of matches 19609
Number of matches After Lowe's Ratio 6929
Number of Robust matches 5222


 85%|████████    | 50/59 [01:33<00:15,  1.72s/it]

Number of matches 20830
```

```
Number of matches After Lowe's Ratio 4534
Number of Robust matches 2895
```

 86%|████████▊ | 51/59 [01:35<00:13, 1.74s/it]

```
Number of matches 20716
Number of matches After Lowe's Ratio 7899
Number of Robust matches 5354
```

 88%|████████▉ | 52/59 [01:36<00:11, 1.68s/it]

```
Number of matches 13601
Number of matches After Lowe's Ratio 2378
Number of Robust matches 1539
```

 90%|█████████ | 53/59 [01:37<00:08, 1.43s/it]

```
Number of matches 11003
Number of matches After Lowe's Ratio 2964
Number of Robust matches 1572
```

 92%|█████████▏ | 54/59 [01:38<00:06, 1.20s/it]

```
Number of matches 11226
Number of matches After Lowe's Ratio 1721
Number of Robust matches 867
```

 93%|█████████▎ | 55/59 [01:39<00:04, 1.06s/it]

```
Number of matches 12178
Number of matches After Lowe's Ratio 3768
Number of Robust matches 2395
```

 95%|█████████▍ | 56/59 [01:40<00:03, 1.02s/it]

```
Number of matches 17658
Number of matches After Lowe's Ratio 3017
Number of Robust matches 2018
```

 97%|█████████▋ | 57/59 [01:41<00:02, 1.15s/it]

```
Number of matches 20009
Number of matches After Lowe's Ratio 5649
Number of Robust matches 3697
```

 98%|█████████▊ | 58/59 [01:43<00:01, 1.28s/it]

```
Number of matches 20037
Number of matches After Lowe's Ratio 5298
Number of Robust matches 3148
```

In [27]:

```
omax,omin,umax,umin,T,H,W,HT = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_kaze,H_right_kaze)
```

Step1:Done

Step2:Done

In [29]:

```
warp_img_kaze = final_steps_left_union(images_left_bgr_no_enhance,H_left_kaze,omax,omin,u
max,umin,T,H,W,HT)
```

```
----------------------------------------------------------------------------
error                                    Traceback (most recent call last)
<ipython-input-29-8d82fc5a0609> in <module>()
----> 1 warp_img_kaze = final_steps_left_union(images_left_bgr_no_enhance,H_left_kaze,oma
x,omin,umax,umin,T,H,W,HT)

<ipython-input-26-81d36fa08a8e> in final_steps_left_union(images_left, H_left, xmax, xmin
, ymax, ymin, t, h, w, Ht)
      6            else:
      7                H_trans = H_trans@H
----> 8                result =  cv2.warpPerspective(images_left[j+1],H_trans,(xmax-xmin,ymax-y
min))
      9                warp_img_init_curr = result
     10

error: OpenCV(3.4.2) /io/opencv/modules/core/src/alloc.cpp:55: error: (-4:Insufficient me
mory) Failed to allocate 315303153255600 bytes in function 'OutOfMemoryError'
```

In [30]:

```
warp_imgs_all_kaze = final_step_right_union(warp_img_kaze,images_right_bgr_no_enhance,H_r
ight_kaze,omax,omin,umax,umin,T,H,W,HT)
```

```
----------------------------------------------------------------------------
NameError                                Traceback (most recent call last)
<ipython-input-30-8259c66da957> in <module>()
----> 1 warp_imgs_all_kaze = final_step_right_union(warp_img_kaze,images_right_bgr_no_enh
ance,H_right_kaze,omax,omin,umax,umin,T,H,W,HT)

NameError: name 'warp_img_kaze' is not defined
```

In [ ]:

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

For SuperPoint 110 images

In [16]:

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

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

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

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

for rfpth in tqdm(images_right):
```

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

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

  0%| | 0/51 [00:00<?, ?it/s]/usr/local/lib/python3.7/dist-packages/torch/nn/fun
ctional.py:718: UserWarning: Named tensors and all their associated APIs are an experimen
tal feature and subject to change. Please do not use them for anything important until th
ey are released as stable. (Triggered internally at /pytorch/c10/core/TensorImpl.h:1156.
)
  return torch.max_pool2d(input, kernel_size, stride, padding, dilation, ceil_mode)

Number of pts selected: 54477

/usr/local/lib/python3.7/dist-packages/torch/nn/functional.py:3982: UserWarning: Default
grid_sample and affine_grid behavior has changed to align_corners=False since 1.3.0. Plea
se specify align_corners=True if the old behavior is desired. See the documentation of gr
id_sample for details.
  "Default grid_sample and affine_grid behavior has changed "
  2%| | 1/51 [00:00<00:28, 1.77it/s]

Number of pts selected: 64559

  4%| | 2/51 [00:00<00:25, 1.91it/s]

Number of pts selected: 62731

  6%| | 3/51 [00:01<00:23, 2.04it/s]

Number of pts selected: 66915

  8%| | 4/51 [00:01<00:22, 2.11it/s]

Number of pts selected: 65977

 10%| | 5/51 [00:02<00:20, 2.20it/s]

Number of pts selected: 62256

 12%| | 6/51 [00:02<00:19, 2.29it/s]

Number of pts selected: 58442

 14%| | 7/51 [00:03<00:18, 2.38it/s]

Number of pts selected: 52856

 16%| | 8/51 [00:03<00:17, 2.45it/s]

Number of pts selected: 53728

 18%| | 9/51 [00:03<00:16, 2.54it/s]

Number of pts selected: 52870

 22%| | 11/51 [00:04<00:15, 2.64it/s]

Number of pts selected: 48261
Number of pts selected: 53550

 24%| | 12/51 [00:04<00:14, 2.66it/s]

Number of pts selected: 53339

 25%| | 13/51 [00:05<00:14, 2.68it/s]

Number of pts selected: 55541

 27%| | 14/51 [00:05<00:13, 2.67it/s]

Number of pts selected: 53723

 29%| | 15/51 [00:05<00:13, 2.69it/s]

Number of pts selected: 63642
```

```
 31%|███        | 16/51 [00:06<00:13,  2.62it/s]
Number of pts selected: 63850
 33%|███        | 17/51 [00:06<00:13,  2.58it/s]
Number of pts selected: 63381
 35%|███        | 18/51 [00:07<00:12,  2.55it/s]
Number of pts selected: 57585
 39%|███        | 20/51 [00:07<00:11,  2.68it/s]
Number of pts selected: 45310
 41%|████       | 21/51 [00:08<00:10,  2.77it/s]
Number of pts selected: 43137
 43%|████       | 22/51 [00:08<00:09,  2.90it/s]
Number of pts selected: 32917
 45%|████       | 23/51 [00:08<00:09,  2.98it/s]
Number of pts selected: 36228
 47%|████       | 24/51 [00:09<00:08,  3.05it/s]
Number of pts selected: 36082
 49%|████       | 25/51 [00:09<00:08,  3.10it/s]
Number of pts selected: 35452
 51%|█████      | 26/51 [00:09<00:08,  3.09it/s]
Number of pts selected: 41594
 53%|█████      | 27/51 [00:10<00:07,  3.09it/s]
Number of pts selected: 41845
Number of pts selected: 52565
 55%|█████      | 28/51 [00:10<00:07,  2.97it/s]
Number of pts selected: 51583
 57%|█████      | 29/51 [00:10<00:07,  2.92it/s]
Number of pts selected: 53864
 59%|██████     | 30/51 [00:11<00:07,  2.85it/s]
Number of pts selected: 51580
 61%|██████     | 31/51 [00:11<00:07,  2.81it/s]
Number of pts selected: 52497
 63%|██████     | 32/51 [00:11<00:06,  2.76it/s]
Number of pts selected: 53351
 65%|██████     | 33/51 [00:12<00:06,  2.75it/s]
Number of pts selected: 58937
 67%|███████    | 34/51 [00:12<00:06,  2.66it/s]
Number of pts selected: 63670
 69%|███████    | 35/51 [00:13<00:06,  2.61it/s]
Number of pts selected: 63164
 71%|███████    | 36/51 [00:13<00:05,  2.57it/s]
Number of pts selected: 61341
```

```
 73%|███████    | 37/51 [00:13<00:05,  2.55it/s]
Number of pts selected: 62577
 75%|███████    | 38/51 [00:14<00:05,  2.55it/s]
Number of pts selected: 60963
 76%|███████    | 39/51 [00:14<00:04,  2.54it/s]
Number of pts selected: 59765
 78%|███████    | 40/51 [00:15<00:04,  2.53it/s]
Number of pts selected: 59418
 80%|███████    | 41/51 [00:15<00:03,  2.53it/s]
Number of pts selected: 57060
 82%|███████    | 42/51 [00:15<00:03,  2.55it/s]
Number of pts selected: 60042
 84%|████████   | 43/51 [00:16<00:03,  2.56it/s]
Number of pts selected: 60481
 86%|████████   | 44/51 [00:16<00:02,  2.55it/s]
Number of pts selected: 61320
 88%|████████   | 45/51 [00:17<00:02,  2.55it/s]
Number of pts selected: 60847
 90%|████████   | 46/51 [00:17<00:01,  2.56it/s]
Number of pts selected: 57839
 92%|████████   | 47/51 [00:17<00:01,  2.56it/s]
Number of pts selected: 59702
 94%|█████████  | 48/51 [00:18<00:01,  2.57it/s]
Number of pts selected: 58094
 96%|█████████  | 49/51 [00:18<00:00,  2.57it/s]
Number of pts selected: 59875
 98%|█████████  | 50/51 [00:19<00:00,  2.58it/s]
Number of pts selected: 57318
100%|██████████| 51/51 [00:19<00:00,  2.63it/s]
  0%|          | 0/59 [00:00<?, ?it/s]
Number of pts selected: 56486
  3%|          | 2/59 [00:00<00:20,  2.72it/s]
Number of pts selected: 43863
  5%|          | 3/59 [00:01<00:20,  2.75it/s]
Number of pts selected: 50000
  7%|          | 4/59 [00:01<00:19,  2.82it/s]
Number of pts selected: 43516
  8%|          | 5/59 [00:01<00:18,  2.89it/s]
Number of pts selected: 41297
 10%|          | 6/59 [00:02<00:18,  2.93it/s]
```

```
Number of pts selected: 42597
 12%|█              | 7/59 [00:02<00:17,  2.92it/s]
Number of pts selected: 44806
 14%|█              | 8/59 [00:02<00:17,  2.94it/s]
Number of pts selected: 43315
 15%|██             | 9/59 [00:03<00:16,  2.98it/s]
Number of pts selected: 39997
 17%|██             | 10/59 [00:03<00:16,  3.04it/s]
Number of pts selected: 37697
 19%|██             | 11/59 [00:03<00:15,  3.01it/s]
Number of pts selected: 41027
 20%|██             | 12/59 [00:04<00:15,  3.00it/s]
Number of pts selected: 45908
 22%|██             | 13/59 [00:04<00:15,  2.94it/s]
Number of pts selected: 49188
Number of pts selected: 57475
 24%|██             | 14/59 [00:04<00:15,  2.84it/s]
Number of pts selected: 55483
 25%|███            | 15/59 [00:05<00:15,  2.79it/s]
Number of pts selected: 52557
 27%|███            | 16/59 [00:05<00:15,  2.76it/s]
Number of pts selected: 55422
 29%|███            | 17/59 [00:05<00:15,  2.72it/s]
Number of pts selected: 54316
 32%|████           | 19/59 [00:06<00:14,  2.72it/s]
Number of pts selected: 51662
 34%|████           | 20/59 [00:07<00:14,  2.75it/s]
Number of pts selected: 50162
 36%|████           | 21/59 [00:07<00:13,  2.77it/s]
Number of pts selected: 48664
 37%|████           | 22/59 [00:07<00:13,  2.82it/s]
Number of pts selected: 46023
 39%|█████          | 23/59 [00:08<00:12,  2.83it/s]
Number of pts selected: 48049
Number of pts selected: 57650
 41%|█████          | 24/59 [00:08<00:12,  2.77it/s]
Number of pts selected: 70799
 42%|█████          | 25/59 [00:08<00:12,  2.63it/s]
Number of pts selected: 72440
 44%|█████          | 26/59 [00:09<00:13,  2.51it/s]
Number of pts selected: 75195
```

```
 46%|████      | 27/59 [00:09<00:13,  2.43it/s]
Number of pts selected: 72197
 47%|████▏     | 28/59 [00:10<00:12,  2.41it/s]
Number of pts selected: 66163
 49%|████▏     | 29/59 [00:10<00:12,  2.39it/s]
Number of pts selected: 59430
 51%|████▍     | 30/59 [00:10<00:11,  2.45it/s]
Number of pts selected: 61074
 53%|████▌     | 31/59 [00:11<00:11,  2.43it/s]
Number of pts selected: 50121
 56%|████▊     | 33/59 [00:12<00:09,  2.66it/s]
Number of pts selected: 33851
 58%|████▉     | 34/59 [00:12<00:08,  2.80it/s]
Number of pts selected: 32768
 59%|█████     | 35/59 [00:12<00:08,  2.89it/s]
Number of pts selected: 36270
Number of pts selected: 50163
 61%|█████▏    | 36/59 [00:13<00:08,  2.84it/s]
Number of pts selected: 47558
 63%|█████▎    | 37/59 [00:13<00:07,  2.80it/s]
Number of pts selected: 54703
 64%|█████▍    | 38/59 [00:13<00:07,  2.76it/s]
Number of pts selected: 60403
 66%|█████▌    | 39/59 [00:14<00:07,  2.66it/s]
Number of pts selected: 73839
 68%|█████▊    | 40/59 [00:14<00:07,  2.53it/s]
Number of pts selected: 72110
 69%|█████▉    | 41/59 [00:15<00:07,  2.45it/s]
Number of pts selected: 70240
 71%|██████    | 42/59 [00:15<00:07,  2.41it/s]
Number of pts selected: 65699
 73%|██████▏   | 43/59 [00:15<00:06,  2.42it/s]
Number of pts selected: 63686
 75%|██████▍   | 44/59 [00:16<00:06,  2.43it/s]
Number of pts selected: 57061
 78%|██████▋   | 46/59 [00:17<00:04,  2.61it/s]
Number of pts selected: 44654
 80%|██████▊   | 47/59 [00:17<00:04,  2.71it/s]
Number of pts selected: 42427
 81%|██████▉   | 48/59 [00:17<00:03,  2.75it/s]
Number of pts selected: 41848
```

```
 83%|████████▍  | 49/59 [00:18<00:03,  2.80it/s]
```

Number of pts selected: 43600

```
 85%|████████▌  | 50/59 [00:18<00:03,  2.84it/s]
```

Number of pts selected: 42041

```
 86%|████████▋  | 51/59 [00:18<00:02,  2.87it/s]
```

Number of pts selected: 44061

```
 88%|████████▊  | 52/59 [00:19<00:02,  2.90it/s]
```

Number of pts selected: 44166

```
 90%|████████▉  | 53/59 [00:19<00:02,  2.87it/s]
```

Number of pts selected: 46081

```
 92%|█████████▏ | 54/59 [00:19<00:01,  2.90it/s]
```

Number of pts selected: 41958

```
 93%|█████████▎ | 55/59 [00:20<00:01,  2.94it/s]
```

Number of pts selected: 41057

```
 95%|█████████▍ | 56/59 [00:20<00:01,  2.92it/s]
```

Number of pts selected: 41750

```
 97%|█████████▋ | 57/59 [00:20<00:00,  2.94it/s]
```

Number of pts selected: 43361

```
 98%|█████████▊ | 58/59 [00:21<00:00,  2.94it/s]
```

Number of pts selected: 45194

```
100%|██████████| 59/59 [00:21<00:00,  2.89it/s]
```

Number of pts selected: 46811

```
100%|██████████| 59/59 [00:21<00:00,  2.74it/s]
```

In [17]:

```python
num_kps_superpoint = []
for j in tqdm(keypoint_all_left_superpoint + keypoints_all_right_superpoint):
  num_kps_superpoint.append(len(j))
```

```
100%|██████████| 110/110 [00:00<00:00, 48905.39it/s]
```

In [21]:

```python
H_left_superpoint = []
H_right_superpoint = []

num_matches_superpoint = []
num_good_matches_superpoint = []

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],keypoint_all_left_
superpoint[j:j+2][::-1],point_all_left_superpoint[j:j+2][::-1],descriptor_all_left_super
point[j:j+2][::-1])
    H_left_superpoint.append(H_a)
    num_matches_superpoint.append(matches)
    num_good_matches_superpoint.append(gd_matches)

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

```
        break

    H_a,matches,gd_matches = get_Hmatrix(images_right_bgr[j:j+2][::-1],keypoints_all_rig
ht_superpoint[j:j+2][::-1],points_all_right_superpoint[j:j+2][::-1],descriptors_all_righ
t_superpoint[j:j+2][::-1])
    H_right_superpoint.append(H_a)
    num_matches_superpoint.append(matches)
    num_good_matches_superpoint.append(gd_matches)
```

  2%|▏ | 1/51 [00:00<00:22, 2.27it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 279
Number of Robust matches 57

  4%|▎ | 2/51 [00:00<00:21, 2.30it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 119
Number of Robust matches 36

  6%|▌ | 3/51 [00:01<00:21, 2.27it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 126
Number of Robust matches 33

  8%|▊ | 4/51 [00:01<00:20, 2.28it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 223
Number of Robust matches 58

 10%|▉ | 5/51 [00:02<00:20, 2.29it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 213
Number of Robust matches 53

 12%|█▏ | 6/51 [00:02<00:19, 2.29it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 129
Number of Robust matches 36

 14%|█▍ | 7/51 [00:03<00:19, 2.28it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 231
Number of Robust matches 46

 16%|█▌ | 8/51 [00:03<00:19, 2.23it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 256
Number of Robust matches 59

 18%|█▊ | 9/51 [00:04<00:19, 2.19it/s]

Number of matches 2000

```
Number of matches After Lowe's Ratio 322
Number of Robust matches 68


 20%|██         | 10/51 [00:04<00:18,  2.19it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 221
Number of Robust matches 51


 22%|██         | 11/51 [00:04<00:18,  2.21it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 200
Number of Robust matches 49


 24%|██         | 12/51 [00:05<00:17,  2.17it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 238
Number of Robust matches 42


 25%|██         | 13/51 [00:05<00:17,  2.19it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 116
Number of Robust matches 24


 27%|██         | 14/51 [00:06<00:16,  2.18it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 167
Number of Robust matches 30


 29%|██         | 15/51 [00:06<00:16,  2.24it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 58
Number of Robust matches 17


 31%|███        | 16/51 [00:07<00:15,  2.28it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 69
Number of Robust matches 21


 33%|███        | 17/51 [00:07<00:15,  2.25it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 208
Number of Robust matches 47


 35%|███        | 18/51 [00:08<00:15,  2.20it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 84
Number of Robust matches 19
```

```
 37%|███         | 19/51 [00:08<00:14,  2.18it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 46
Number of Robust matches 7


 39%|███         | 20/51 [00:09<00:14,  2.15it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 154
Number of Robust matches 23


 41%|███         | 21/51 [00:09<00:13,  2.20it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 94
Number of Robust matches 23


 43%|████        | 22/51 [00:09<00:13,  2.22it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 10
Number of Robust matches 4


 45%|████        | 23/51 [00:10<00:12,  2.27it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 239
Number of Robust matches 37


 47%|████        | 24/51 [00:10<00:12,  2.23it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 248
Number of Robust matches 38


 49%|████        | 25/51 [00:11<00:11,  2.22it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 186
Number of Robust matches 30


 51%|█████       | 26/51 [00:11<00:11,  2.20it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 253
Number of Robust matches 49


 53%|█████       | 27/51 [00:12<00:11,  2.18it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 199
Number of Robust matches 26


 55%|█████       | 28/51 [00:12<00:10,  2.19it/s]
```

```
Number of matches 2000
Number of matches After Lowe's Ratio 232
Number of Robust matches 29


 57%|███████     | 29/51 [00:13<00:09,  2.21it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 152
Number of Robust matches 27


 59%|███████     | 30/51 [00:13<00:09,  2.20it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 213
Number of Robust matches 34


 61%|███████     | 31/51 [00:13<00:08,  2.24it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 230
Number of Robust matches 45


 63%|███████     | 32/51 [00:14<00:08,  2.30it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 229
Number of Robust matches 60


 65%|████████    | 33/51 [00:14<00:07,  2.32it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 289
Number of Robust matches 69


 67%|████████    | 34/51 [00:15<00:07,  2.31it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 168
Number of Robust matches 30


 69%|████████    | 35/51 [00:15<00:07,  2.26it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 196
Number of Robust matches 36


 71%|████████    | 36/51 [00:16<00:06,  2.26it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 212
Number of Robust matches 51


 73%|████████    | 37/51 [00:16<00:06,  2.23it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 190
Number of Robust matches 43
```

```
 75%|███████▌   | 38/51 [00:17<00:05,  2.21it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 128
Number of Robust matches 25


 76%|███████▋   | 39/51 [00:17<00:05,  2.19it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 367
Number of Robust matches 71


 78%|███████▊   | 40/51 [00:17<00:05,  2.19it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 309
Number of Robust matches 55


 80%|████████   | 41/51 [00:18<00:04,  2.19it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 194
Number of Robust matches 37


 82%|████████▏  | 42/51 [00:18<00:04,  2.19it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 180
Number of Robust matches 39


 84%|████████▍  | 43/51 [00:19<00:03,  2.14it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 222
Number of Robust matches 47


 86%|████████▌  | 44/51 [00:19<00:03,  2.13it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 98
Number of Robust matches 24


 88%|████████▊  | 45/51 [00:20<00:02,  2.21it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 156
Number of Robust matches 39


 90%|█████████  | 46/51 [00:20<00:02,  2.22it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 150
Number of Robust matches 30


 92%|█████████▏ | 47/51 [00:21<00:01,  2.18it/s]
```

```
Number of matches 2000
Number of matches After Lowe's Ratio 243
Number of Robust matches 59


 94%|████████▊ | 48/51 [00:21<00:01,  2.18it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 83
Number of Robust matches 13


 96%|████████▉ | 49/51 [00:22<00:00,  2.16it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 196
Number of Robust matches 29


  0%|          | 0/59 [00:00<?, ?it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 32
Number of Robust matches 7


  2%|▏         | 1/59 [00:00<00:27,  2.09it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 80
Number of Robust matches 15


  3%|▎         | 2/59 [00:00<00:27,  2.09it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 90
Number of Robust matches 19


  5%|▌         | 3/59 [00:01<00:26,  2.09it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 142
Number of Robust matches 33


  7%|▋         | 4/59 [00:01<00:26,  2.11it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 232
Number of Robust matches 46


  8%|▊         | 5/59 [00:02<00:26,  2.07it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 139
Number of Robust matches 31


 10%|█         | 6/59 [00:02<00:25,  2.05it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 203
Number of Robust matches 42
```

```
 12%|█          | 7/59 [00:03<00:24,  2.08it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 14
Number of Robust matches 4

```
 14%|█          | 8/59 [00:03<00:24,  2.10it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 59
Number of Robust matches 12

```
 15%|█          | 9/59 [00:04<00:23,  2.11it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 48
Number of Robust matches 11

```
 17%|█          | 10/59 [00:04<00:23,  2.10it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 212
Number of Robust matches 39

```
 19%|█          | 11/59 [00:05<00:22,  2.15it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 282
Number of Robust matches 72

```
 20%|██         | 12/59 [00:05<00:21,  2.18it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 332
Number of Robust matches 77

```
 22%|██         | 13/59 [00:06<00:21,  2.15it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 118
Number of Robust matches 23

```
 24%|██         | 14/59 [00:06<00:20,  2.15it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 25
Number of Robust matches 7

```
 25%|██         | 15/59 [00:07<00:20,  2.17it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 216
Number of Robust matches 63

```
 27%|██         | 16/59 [00:07<00:19,  2.15it/s]
```

```
Number of matches 2000
Number of matches After Lowe's Ratio 116
Number of Robust matches 27


 29%|██        | 17/59 [00:08<00:19,  2.13it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 384
Number of Robust matches 87


 31%|███       | 18/59 [00:08<00:19,  2.12it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 256
Number of Robust matches 60


 32%|███       | 19/59 [00:08<00:18,  2.12it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 229
Number of Robust matches 55


 34%|███       | 20/59 [00:09<00:18,  2.16it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 296
Number of Robust matches 73


 36%|███       | 21/59 [00:09<00:17,  2.20it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 118
Number of Robust matches 28


 37%|███       | 22/59 [00:10<00:17,  2.16it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 197
Number of Robust matches 43


 39%|███       | 23/59 [00:10<00:16,  2.14it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 206
Number of Robust matches 38


 41%|████      | 24/59 [00:11<00:16,  2.14it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 203
Number of Robust matches 35


 42%|████      | 25/59 [00:11<00:16,  2.12it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 227
Number of Robust matches 32
```

```
 44%|████       | 26/59 [00:12<00:15,  2.10it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 236
Number of Robust matches 33


 46%|████       | 27/59 [00:12<00:15,  2.08it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 197
Number of Robust matches 31


 47%|████       | 28/59 [00:13<00:14,  2.09it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 367
Number of Robust matches 48


 49%|████       | 29/59 [00:13<00:14,  2.08it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 283
Number of Robust matches 39


 51%|█████      | 30/59 [00:14<00:13,  2.10it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 187
Number of Robust matches 48


 53%|█████      | 31/59 [00:14<00:13,  2.12it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 180
Number of Robust matches 43


 54%|█████      | 32/59 [00:15<00:12,  2.17it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 23
Number of Robust matches 6


 56%|█████      | 33/59 [00:15<00:12,  2.15it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 62
Number of Robust matches 14


 58%|█████      | 34/59 [00:15<00:11,  2.18it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 11
Number of Robust matches 4


 59%|██████     | 35/59 [00:16<00:11,  2.14it/s]
```

```
Number of matches 2000
Number of matches After Lowe's Ratio 105
Number of Robust matches 24


 61%|███████      | 36/59 [00:16<00:10,  2.16it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 323
Number of Robust matches 43


 63%|███████      | 37/59 [00:17<00:10,  2.02it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 250
Number of Robust matches 28


 64%|███████      | 38/59 [00:17<00:10,  2.07it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 181
Number of Robust matches 28


 66%|███████      | 39/59 [00:18<00:09,  2.03it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 200
Number of Robust matches 35


 68%|███████      | 40/59 [00:18<00:09,  2.05it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 130
Number of Robust matches 17


 69%|███████      | 41/59 [00:19<00:08,  2.06it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 338
Number of Robust matches 50


 71%|███████      | 42/59 [00:19<00:08,  2.08it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 130
Number of Robust matches 25


 73%|███████      | 43/59 [00:20<00:07,  2.11it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 148
Number of Robust matches 38


 75%|███████      | 44/59 [00:20<00:07,  2.13it/s]

Number of matches 2000
Number of matches After Lowe's Ratio 267
Number of Robust matches 57
```

```
76%|█████     | 45/59 [00:21<00:06,  2.19it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 136
Number of Robust matches 30

```
78%|██████    | 46/59 [00:21<00:05,  2.22it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 68
Number of Robust matches 22

```
80%|██████    | 47/59 [00:22<00:05,  2.21it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 290
Number of Robust matches 69

```
81%|███████   | 48/59 [00:22<00:05,  2.19it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 179
Number of Robust matches 45

```
83%|███████   | 49/59 [00:23<00:04,  2.21it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 515
Number of Robust matches 172

```
85%|████████  | 50/59 [00:23<00:04,  2.17it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 149
Number of Robust matches 32

```
86%|████████  | 51/59 [00:23<00:03,  2.14it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 348
Number of Robust matches 80

```
88%|████████  | 52/59 [00:24<00:03,  2.11it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 56
Number of Robust matches 10

```
90%|█████████ | 53/59 [00:24<00:02,  2.15it/s]
```

Number of matches 2000
Number of matches After Lowe's Ratio 135
Number of Robust matches 29

```
92%|█████████ | 54/59 [00:25<00:02,  2.25it/s]
```

```
Number of matches 2000
Number of matches After Lowe's Ratio 94
Number of Robust matches 30
```

93%|██████████| 55/59 [00:25<00:01, 2.22it/s]

```
Number of matches 2000
Number of matches After Lowe's Ratio 464
Number of Robust matches 110
```

95%|██████████| 56/59 [00:26<00:01, 2.22it/s]

```
Number of matches 2000
Number of matches After Lowe's Ratio 186
Number of Robust matches 35
```

97%|██████████| 57/59 [00:26<00:00, 2.21it/s]

```
Number of matches 2000
Number of matches After Lowe's Ratio 322
Number of Robust matches 55
```

98%|██████████| 58/59 [00:27<00:00, 2.19it/s]

```
Number of matches 2000
Number of matches After Lowe's Ratio 252
Number of Robust matches 49
```

In [24]:

```python
xmax,xmin,ymax,ymin,t,h,w,Ht = warpnImages(images_left_bgr_no_enhance, images_right_bgr_
no_enhance,H_left_superpoint,H_right_superpoint)
```

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

In [ ]:

```python
warp_imgs_left = final_steps_left_union(images_left_bgr_no_enhance,H_left_superpoint,xmax
,xmin,ymax,ymin,t,h,w,Ht)
```

In [ ]:

```python
warp_imgs_all_mser = final_step_right_union(warp_imgs_left,images_right_bgr_no_enhance,H_
right_superpoint,xmax,xmin,ymax,ymin,t,h,w,Ht)
```

In [ ]: