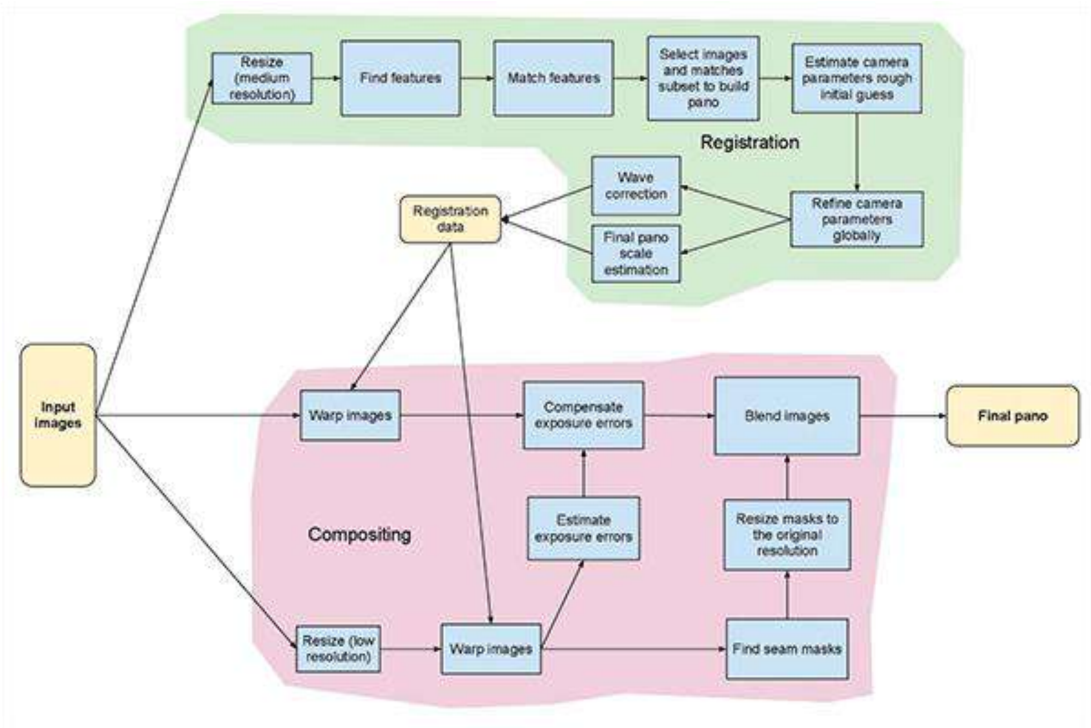
Image Stitching/Orthomosaic

Let's first understand the concept of mosaicking or image stitching. Basically if you want to capture a big scene. Now your camera can only provide an image of a specific resolution and that resolution , say 640 by 480 , is certainly not enough to capture the big panoramic view. So , what one can do is capture multiple images of the entire scene and then put together all bits and pieces into one big mat of images. Yes, it seems good .. right ! Such photographs , which pose as an ordered collection of a scene are called as mosaics or panoramas. The entire process of acquiring multiple image and converting them into such panoramas is called as image mosaicking. And finally, we have one beautiful big and large photograph of the scenic view.



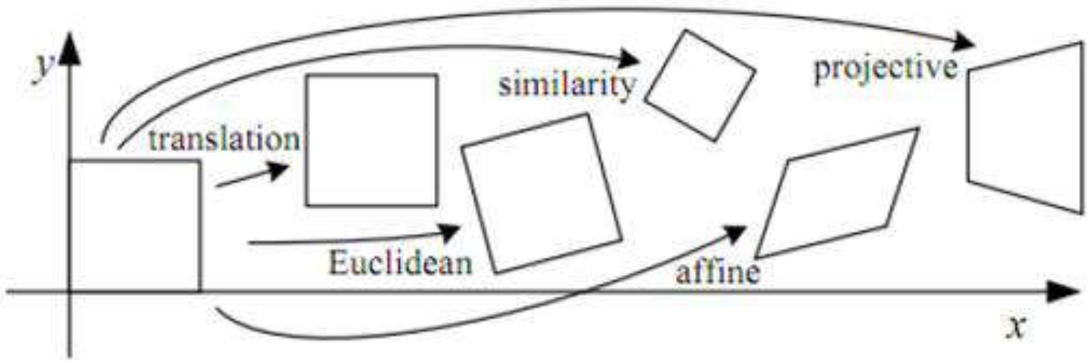
Another method for achieving this, is by using wide angle lens in your camera. What a wide angle lens does, is effectively increase your field of view. The output, will differ (obviously).

Homography

Okay, so assume you're looking at a scenery. You will be having a field of view and that field of view is of what you want to make a panorama. You can rotate your head and cover a big area. But while you are looking straight, looking directly perpendicularly at a sub-scene, the remaining part of the scenery appears slightly inclined or slightly narrowed out. This is due to simple physics. Since you are facing in one direction, the things to your extreme periphery appears unclear, reduced in dimension and not necessarily straight/normal (a bit inclined). This is exactly what we will be exploiting.

Consider the images shown in the above figure. Every image will contain some common portion with the other images. Due to this commonness we are able to say that image x will either lie on to the right or left side of image y .

Anyway, now that I've made that clear, let's proceed as to how do we calculate homography. Say you have a pair of images I1 , I2 . You capture the first image. Then you decide to rotate your camera, or maybe perform some translation or maybe a combination of rotation / translation motion. Then having update your new camera position , you capture a second image. The problem now at hand is, How do you solve for a system wherein you're required to create a transformation that efficiently maps a point that is being projected in both the images. Or in simple terms, How do you visualize one image w.r.t another point of view, given there is some information available about both your points of views.



Step 1: Feature extraction:

```
sift_obj = cv2.xfeatures2d.SIFT_create()
descriptors, keypoints = sift_obj.detectAndCompute(image_gray, None)
```

Step 2: Matching correspondences between images :

```
# FLANN parameters
FLANN_INDEX_KDTREE = 0
index_params = dict(algorithm = FLANN_INDEX_KDTREE, trees = 5)
search_params = dict(checks=50)     # or pass empty dictionary

flann = cv2.FlannBasedMatcher(index_params,search_params)

matches = flann.knnMatch(des1,des2,k=2)

img3 =
cv2.drawMatchesKnn(img1c,kp1,img2c,kp2,matches,None,**draw_params)

cv2.imshow("correspondences", img3)
cv2.waitKey()
```

Step 3: Compute Homography

```
H, __ = cv2.findHomography(srcPoints, dstPoints, cv2.RANSAC, 4)
```

Step 4 : Warping & Stitching :

```
warped_image = cv2.warpPerspective(image, homography_matrix, dimension_of_warped_image)
```

Stitching ‘em up !

```
def leftstitch(self):
    # self.left_list = reversed(self.left_list)
    a = self.left_list[0]
    for b in self.left_list[1:]:
        H = self.matcher_obj.match(a, b, 'left')
        print "Homography is : ", H
        xh = np.linalg.inv(H)
        print "Inverse Homography :", xh
        # start_p is denoted by f1
        f1 = np.dot(xh, np.array([0,0,1]))
        f1 = f1/f1[-1]
        # transforming the matrix
        xh[0][-1] += abs(f1[0])
        xh[1][-1] += abs(f1[1])
        ds = np.dot(xh, np.array([a.shape[1], a.shape[0], 1]))
        offsety = abs(int(f1[1]))
        offsetx = abs(int(f1[0]))
        # dimension of warped image
        dsize = (int(ds[0])+offsetx, int(ds[1]) + offsety)
        print "image dsize =>", dsize
        tmp = cv2.warpPerspective(a, xh, dsize)
        # cv2.imshow("warped", tmp)
        # cv2.waitKey()
        tmp[offsety:b.shape[0]+offsety, offsetx:b.shape[1]+offsetx] = b
        a = tmp
```

Another method :

```
def mix_match(self, leftImage, warpedImage)
    i1y, i1x = leftImage.shape[:2]
    i2y, i2x = warpedImage.shape[:2]


    for i in range(0, i1x):
```

```
        for j in range(0, i1y):
            try:
                if(np.array_equal(leftImage[j,i],np.array([0,0,0])) and    \
                    np.array_equal(warpedImage[j,i],np.array([0,0,0]))):
                    # print "BLACK"
                    # instead of just putting it with black,
                    # take average of all nearby values and avg it.
                    warpedImage[j,i] = [0, 0, 0]
                else:
                    if(np.array_equal(warpedImage[j,i],[0,0,0])):
                        # print "PIXEL"
                        warpedImage[j,i] = leftImage[j,i]
                    else:
                        if not np.array_equal(leftImage[j,i], [0,0,0]):
                            bl,gl,rl = leftImage[j,i]
                            warpedImage[j, i] = [bl,gl,rl]
            except:
                pass
    # cv2.imshow("waRPED mix", warpedImage)
    # cv2.waitKey()
    return warpedImage
```

After Stitching:

Installing the appropiate version of OpenCV

In [14]:
```
!pip install opencv-contrib-python==3.4.2.16
```

```
Requirement already satisfied: opencv-contrib-python==3.4.2.16 in /usr/local/lib/python3.6/dist-packages (3.4.2.16)
Requirement already satisfied: numpy>=1.11.3 in /usr/local/lib/python3.6/dist-packages (from opencv-contrib-python==
3.4.2.16) (1.18.5)
```

Working on "Gravel Quarry" dataset

Importing packages

In [16]:
```
import cv2
import numpy as np
```

Uploading 2 images

In [59]:
```
img_ = cv2.imread('/content/IX-01-61737_0029_0053.JPG')
img_ = cv2.resize(img_, (0,0), fx=1, fy=1)
img1 = cv2.cvtColor(img_,cv2.COLOR_BGR2GRAY)
img = cv2.imread('/content/IX-01-61737_0029_0054.JPG')
img = cv2.resize(img, (0,0), fx=1, fy=1)
img2 = cv2.cvtColor(img,cv2.COLOR_BGR2GRAY)
```

Finding the key points and descriptors with SIFT

In [60]:
```
sift = cv2.xfeatures2d.SIFT_create()

kp1, des1 = sift.detectAndCompute(img1,None)
kp2, des2 = sift.detectAndCompute(img2,None)
```

Displaying the output on 1st image

In [61]:
```
import matplotlib.pyplot as plt
plt.figure(figsize=(12,8))
# cv2.imshow('original_image_left_keypoints',cv2.drawKeypoints(img_,kp1,None))
plt.imshow(cv2.drawKeypoints(img_,kp1,None))
```

Out[61]:
```
<matplotlib.image.AxesImage at 0x7f3f7e66aa20>
```

Finding the 'Matching' points between two images

FLANN matcher

In [20]:
```
FLANN_INDEX_KDTREE = 0
index_params = dict(algorithm = FLANN_INDEX_KDTREE, trees = 5)
search_params = dict(checks = 50)
match = cv2.FlannBasedMatcher(index_params, search_params)
matches = match.knnMatch(des1,des2,k=2)
```

BFMatcher matcher

In [62]:
```
match = cv2.BFMatcher()
matches = match.knnMatch(des1,des2,k=2)
```

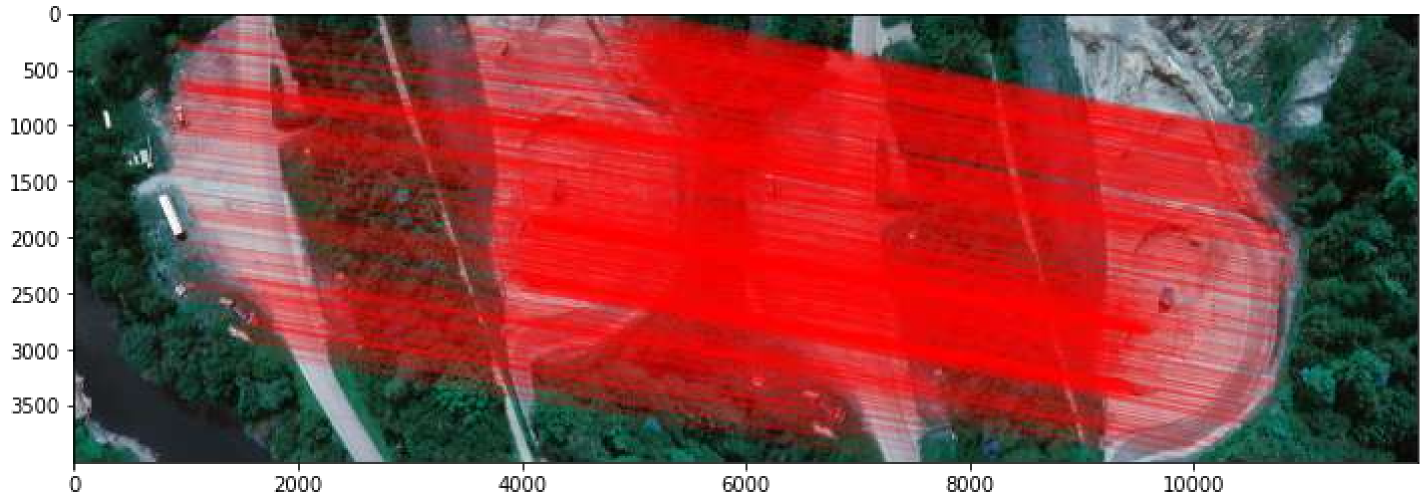
Both will perform the same way and will give same output

In [67]:
```
good = []
for m,n in matches:
    if m.distance < 0.7*n.distance:
        good.append(m)
```

Output image with matches drawn

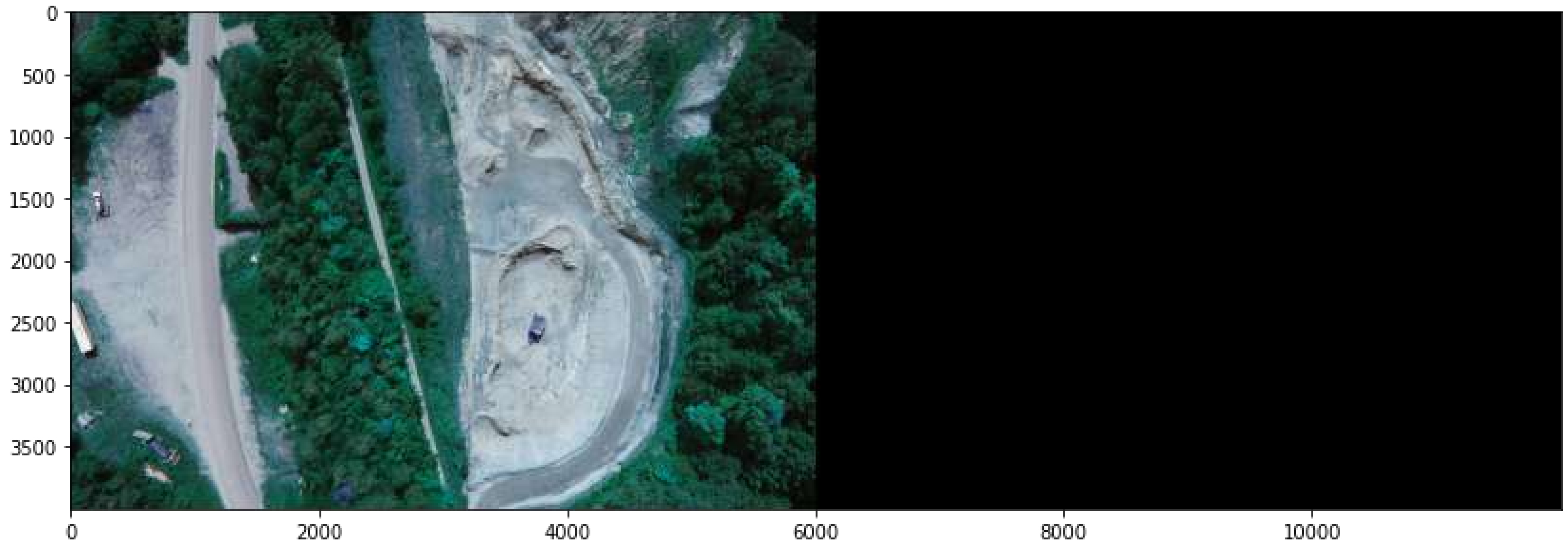
In [69]:
```
draw_params = dict(matchColor = (255,0,0), # draw matches in red color
                   singlePointColor = None,
                   flags = 2)
img3 = cv2.drawMatches(img_,kp1,img,kp2,good,None,**draw_params)
# cv2.imshow("original_image_drawMatches.jpg", img3)
plt.figure(figsize=(12,10))
plt.imshow(img3)
```

Out[69]:
```
<matplotlib.image.AxesImage at 0x7f3f7fdc3a90>
```



In [74]:

```
MIN_MATCH_COUNT = 10
if len(good) > MIN_MATCH_COUNT:
    src_pts = np.float32([ kp1[m.queryIdx].pt for m in good ]).reshape(-1,1,2)
    dst_pts = np.float32([ kp2[m.trainIdx].pt for m in good ]).reshape(-1,1,2)
    M, mask = cv2.findHomography(src_pts, dst_pts, cv2.RANSAC, 5.0)
    h,w = img1.shape
    pts = np.float32([ [0,0],[0,h-1],[w-1,h-1],[w-1,0] ]).reshape(-1,1,2)
    dst = cv2.perspectiveTransform(pts, M)
    img2 = cv2.polylines(img2,[np.int32(dst)],True,255,3, cv2.LINE_AA)
    #cv2.imshow("original_image_overlapping.jpg", img2)
else:
    print("Not enought matches are found - %d/%d", (len(good)/MIN_MATCH_COUNT))
dst = cv2.warpPerspective(img_,M,(img.shape[1] + img_.shape[1], img.shape[0]))
dst[0:img.shape[0],0:img.shape[1]] = img
# cv2.imshow("original_image_stitched.jpg", dst)
plt.figure(figsize=(14,10))
plt.imshow(dst)
```



In [77]:

```
def trim(frame):
    #crop top
    if not np.sum(frame[0]):
        return trim(frame[1:])
    #crop top
    if not np.sum(frame[-1]):
        return trim(frame[:-2])
    #crop top
    if not np.sum(frame[:,0]):
        return trim(frame[:,1:])
    #crop top
    if not np.sum(frame[:,-1]):
        return trim(frame[:,:-2])
    return frame

def crop(image):
  y_nonzero, x_nonzero, _ = np.nonzero(image)
  return image[np.min(y_nonzero):np.max(y_nonzero), np.min(x_nonzero):np.max(x_nonzero)]
```

```
plt.figure(figsize=(12,8))
plt.imshow(crop(dst))
```

Out[77]: <matplotlib.image.AxesImage at 0x7f3f7f7f7710>

It seems the output will not be as expected. But, we can notice it is performing our main motive - 'Homography' and 'Matching between images'

Working on "Dam Inspection" dataset

Creating the Matcher class

This deals with:

1. Feature extraction
2. Matching correspondences between images

In [19]:

```
import cv2
import numpy as np

class matchers:
  def __init__(self):
    self.surf = cv2.xfeatures2d.SURF_create()
    FLANN_INDEX_KDTREE = 0
    index_params = dict(algorithm=0, trees=5)
    search_params = dict(checks=50)
    self.flann = cv2.FlannBasedMatcher(index_params, search_params)

  def match(self, i1, i2, direction=None):
    imageSet1 = self.getSURFFeatures(i1)
    imageSet2 = self.getSURFFeatures(i2)
    print("Direction : ", direction)
    matches = self.flann.knnMatch(imageSet2['des'], imageSet1['des'], k=2)
    good = []
    for i , (m, n) in enumerate(matches):
      if m.distance < 0.7*n.distance:
        good.append((m.trainIdx, m.queryIdx))

    if len(good) > 4:
      pointsCurrent = imageSet2['kp']
      pointsPrevious = imageSet1['kp']

      matchedPointsCurrent = np.float32( [pointsCurrent[i].pt for (_, i) in good])
      matchedPointsPrev = np.float32( [pointsPrevious[i].pt for (i,_ ) in good])

      H, s = cv2.findHomography(matchedPointsCurrent, matchedPointsPrev, cv2.RANSAC, 4)
      return H
    return None

  def getSURFFeatures(self, im):
```

```
    gray = cv2.cvtColor(im, cv2.COLOR_BGR2GRAY)
    kp, des = self.surf.detectAndCompute(gray, None)
    return {'kp':kp, 'des':des}
```

Creating Panorama class

This deals with:

1. Compute Homography
2. Wrapping ans Stitching

In [79]:

```
import numpy as np
import cv2
import sys
from matchers import Matchers
import time
import matplotlib.pyplot as plt

class Stitch:
  def __init__(self, args):
    self.path = '/content/txtlists/files1.txt'
    fp = open(self.path, 'r')
    filenames = [each.rstrip('\r\n') for each in fp.readlines()]
    print(filenames)
    self.images = [cv2.resize(cv2.imread(each),(427, 320)) for each in filenames]
    self.count = len(self.images)
    self.left_list, self.right_list, self.center_im = [], [],None
    self.matcher_obj = Matchers()
    self.prepare_lists()

  def prepare_lists(self):
    print("Number of images : %d"%self.count)
    self.centerIdx = self.count/2
    print("Center index image : %d"%self.centerIdx)
    self.center_im = self.images[int(self.centerIdx)]
    for i in range(self.count):
      if(i<=self.centerIdx):
        self.left_list.append(self.images[i])
```

```
      else:
        self.right_list.append(self.images[i])
        print("Image lists prepared")

  def leftshift(self):
    # self.left_list = reversed(self.left_list)
    a = self.left_list[0]
    for b in self.left_list[1:]:
      H = self.matcher_obj.match(a, b, direction='left')
      print("Homography is : ", H)
      xh = np.linalg.inv(H)
      print("Inverse Homography :", xh)
      ds = np.dot(xh, np.array([a.shape[1], a.shape[0], 1]));
      ds = ds/ds[-1]
      print("final ds=>", ds)
      f1 = np.dot(xh, np.array([0,0,1]))
      f1 = f1/f1[-1]
      xh[0][-1] += abs(f1[0])
      xh[1][-1] += abs(f1[1])
      ds = np.dot(xh, np.array([a.shape[1], a.shape[0], 1]))
      offsety = abs(int(f1[1]))
      offsetx = abs(int(f1[0]))
      dsize = (int(ds[0])+offsetx, int(ds[1]) + offsety)
      print("image dsize =>", dsize)
      tmp = cv2.warpPerspective(a, xh, dsize)
      # cv2.imshow("warped", tmp) # cv2.waitKey()
      tmp[offsety:b.shape[0]+offsety, offsetx:b.shape[1]+offsetx] = b
      a = tmp

    self.leftImage = tmp

  def rightshift(self):
    for each in self.right_list:
      H = self.matcher_obj.match(self.leftImage, each, 'right')
      print("Homography :", H)
      txyz = np.dot(H, np.array([each.shape[1], each.shape[0], 1]))
      txyz = txyz/txyz[-1]
      dsize = (int(txyz[0])+self.leftImage.shape[1],int(txyz[1])+self.leftImage.shape[0])
      tmp = cv2.warpPerspective(each, H, dsize)
```

```
        plt.imshow(tmp)
        plt.show()
        #cv2.waitKey()
        # tmp[:self.leftImage.shape[0], :self.leftImage.shape[1]]=self.leftImage
        tmp = self.mix_and_match(self.leftImage, tmp)
        print("tmp shape",tmp.shape)
        print("self.leftimage shape=", self.leftImage.shape)
        self.leftImage = tmp
        # self.showImage('left')

    def mix_and_match(self, leftImage, warpedImage):
      i1y, i1x = leftImage.shape[:2]
      i2y, i2x = warpedImage.shape[:2]
      print(leftImage[-1,-1])

      t = time.time()
      black_l = np.where(leftImage == np.array([0,0,0]))
      black_wi = np.where(warpedImage == np.array([0,0,0]))
      print(time.time() - t)
      print(black_l[-1])

      for i in range(0, i1x):
        for j in range(0, i1y):
          try:
            if(np.array_equal(leftImage[j,i],np.array([0,0,0])) and np.array_equal(warpedImage[j,i],np.array([0,0,0])))
              # print "BLACK"
              # instead of just putting it with black,
              # take average of all nearby values and avg it.
              warpedImage[j,i] = [0, 0, 0]
            else:
              if(np.array_equal(warpedImage[j,i],[0,0,0])):
                # print "PIXEL"
                warpedImage[j,i] = leftImage[j,i]
              else:
                if not np.array_equal(leftImage[j,i], [0,0,0]):
                  bw, gw, rw = warpedImage[j,i]
                  bl,gl,rl = leftImage[j,i]
                  # b = (bl+bw)/2
                  # g = (gl+gw)/2
```

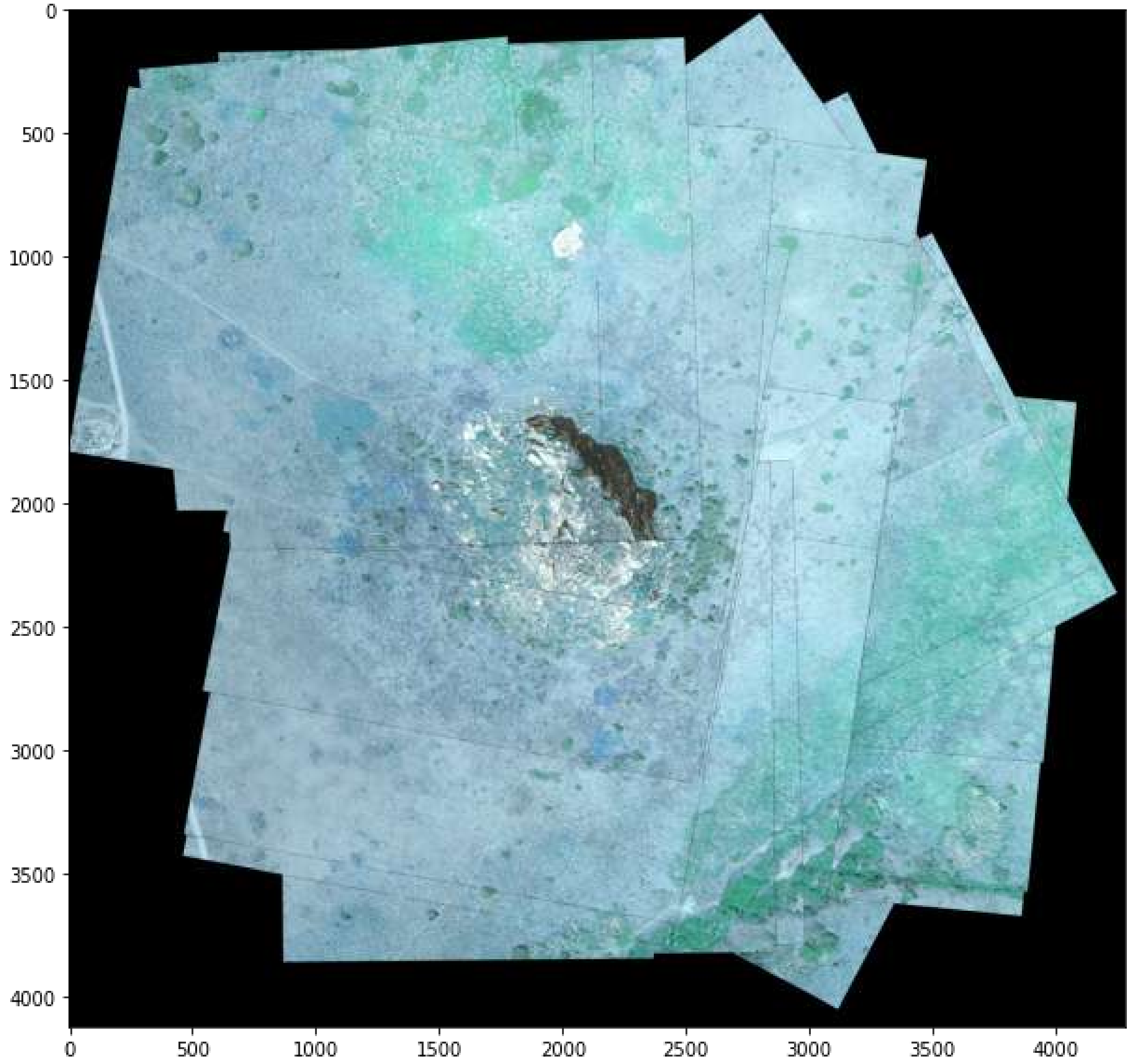
```python
                # r = (rl+rw)/2
                warpedImage[j, i] = [bl,gl,rl]
        except:
          pass
          # cv2.imshow("waRPED mix", warpedImage)
          # cv2.waitKey()
    return warpedImage

  def trim_left(self):
    pass

  def showImage(self, string=None):
    if string == 'left':
      plt.imshow(self.leftImage)
      plt.show()
      # cv2.imshow("left image", cv2.resize(self.leftImage, (400,400)))
    elif string == "right":
      plt.imshow(self.rightImage)
      plt.show()
      #cv2.waitKey()

if __name__ == '__main__':
  try:
    args = sys.argv[1]
  except:
    args = "txtlists/files1.txt"
  finally:
    print("Parameters : ", args)
  s = Stitch(args)
  s.leftshift()
  # s.showImage('left')
  s.rightshift()
  print("Done")
  cv2.imwrite("image_mosaic1.jpg", s.leftImage)
  print("Image written")
  #cv2.destroyAllWindows()
```

```
Parameters :  -f
Number of images : 19
Center index image : 5
```

Image lists prepared

Done

Out[79]: <matplotlib.image.AxesImage at 0x7f3f7f761400>



This seems to perform the actual work of Orthomosaic

Stitches all the images given to it within a textfile

Working on "Small Village" dataset

Importing necessary packages

In [23]:
```
import cv2
import numpy as np
import matplotlib.pyplot as pit
import pandas as pd
from random import randrange
import argparse
import glob
```

Giving/Supplying the required images

In [24]:
```
img1 = cv2.imread(r'/content/IMG_7747.JPG')
img2 = cv2.imread(r'/content/IMG_7748.JPG')
img3 = cv2.imread(r'/content/IMG_7749.JPG')
```

Re-sizing those images

In [26]:
```
img1 = cv2.resize(img1, (0,0), fx=1, fy=1)
img2 = cv2.resize(img2, (0,0), fx=1, fy=1)
img3 = cv2.resize(img3, (0,0), fx=1, fy=1)
```

In [27]:
```
def images_gray(img1,img2,img3):
  imglgray = cv2.cvtColor(img1, cv2.COLOR_RGB2GRAY)
  img2gray = cv2.cvtColor(img2, cv2.COLOR_RGB2GRAY)
  img3gray = cv2.cvtColor(img3, cv2.COLOR_RGB2GRAY)
  return imglgray,img2gray,img3gray
```

In [29]:
```python
img1gray,img2gray,img3gray = images_gray(img1,img2,img3)
```

Changing the color to GrayScale mode

Displaying all the 3 images

In [31]:
```python
figure, ax = plt.subplots(1, 3, figsize=(18, 10))
ax[0].imshow(img1gray, cmap='gray')
ax[1].imshow(img2gray, cmap='gray')
ax[2].imshow(img3gray, cmap='gray')
```

Out[31]: <matplotlib.image.AxesImage at 0x7f3f7ef8e940>

Using the ORB Algorithm

In [33]:
```python
orb = cv2.ORB_create()
#detect keypoints and extract
kp1,des1 = orb.detectAndCompute(img1, None)
kp2,des2 = orb.detectAndCompute(img2, None)
kp3,des3 = orb.detectAndCompute(img3, None)
```

In [34]:
```python
keypoints_with_size1 = np.copy(img1)
keypoints_with_size2 = np.copy(img2)
```

```
keypoints_with_size3 = np.copy(img3)
```

Drawing the keypoints on one of the images given(here, 1st image)

In [35]:

```
cv2.drawKeypoints(img1, kp1, keypoints_with_size1, color=(0,255,0))
```

Out[35]:

```
array([[[ 28,  33,  31],
        [ 28,  33,  31],
        [ 29,  34,  32],
        ...,
        [100, 148, 182],
        [ 93, 141, 175],
        [ 94, 142, 176]],

       [[ 28,  33,  31],
        [ 28,  33,  31],
        [ 29,  34,  32],
        ...,
        [ 93, 141, 175],
        [100, 148, 182],
        [109, 157, 191]],

       [[ 26,  32,  27],
        [ 27,  33,  28],
        [ 27,  33,  28],
        ...,
        [ 97, 142, 179],
        [108, 153, 190],
        [115, 160, 197]],

       ...,

       [[107, 150, 159],
        [108, 151, 160],
        [110, 153, 162],
        ...,
        [ 42,  36,  29],
        [ 42,  36,  29],
        [ 42,  36,  29]],

       [[103, 146, 155],
        [105, 148, 157],
```

```
        [110, 153, 162],
        ...,
        [ 40,  34,  27],
        [ 41,  35,  28],
        [ 44,  38,  31]],

       [[100, 143, 152],
        [105, 148, 157],
        [111, 154, 163],
        ...,
        [ 39,  33,  26],
        [ 41,  35,  28],
        [ 45,  39,  32]]], dtype=uint8)
```

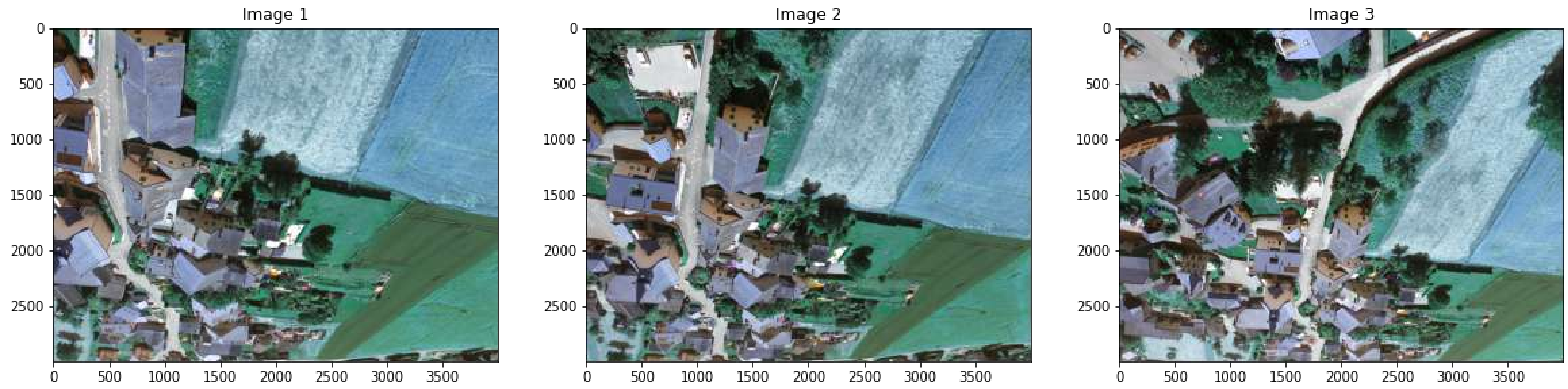
Displaying the keypoints

In [37]:

```
cv2.drawKeypoints(img1, kp1, keypoints_with_size1, flags=cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS)
cv2.drawKeypoints(img2, kp2, keypoints_with_size2, flags=cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS)
cv2.drawKeypoints(img3, kp3, keypoints_with_size3, flags=cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS)
plt.figure(figsize=(20,10))
plt.subplot(1, 3, 1)
plt.title("Image 1")
plt.imshow(keypoints_with_size1, cmap='gray')
plt.subplot(1, 3, 2)
plt.title("Image 2")
plt.imshow(keypoints_with_size2, cmap='gray')
plt.subplot(1, 3, 3)
plt.title("Image 3")
plt.imshow(keypoints_with_size3, cmap='gray')
```

Out[37]:

```
<matplotlib.image.AxesImage at 0x7f3f807092b0>
```



In [38]:

```
print("keypoints: {}, descriptors: {}".format(len(kp1), des1.shape))
print("keypoints: {}, descriptors: {}".format(len(kp2), des2.shape))
print("keypoints: {}, descriptors: {}".format(len(kp3), des3.shape))
```

```
keypoints: 500, descriptors: (500, 32)
keypoints: 500, descriptors: (500, 32)
keypoints: 500, descriptors: (500, 32)
```

Using the SIFT Algorithm

In [39]:

```
sift = cv2.xfeatures2d.SIFT_create()

kp1, des1 = sift.detectAndCompute(img1,None)
kp2, des2 = sift.detectAndCompute(img2,None)
kp3, des3 = sift.detectAndCompute(img3,None)
```

Brute-Force (BF) Matcher

In [40]:

```
match = cv2.BFMatcher()
matches = match.knnMatch(des1,des2,k=2)
print('Number of raw matches: %d.' % len(matches))
```

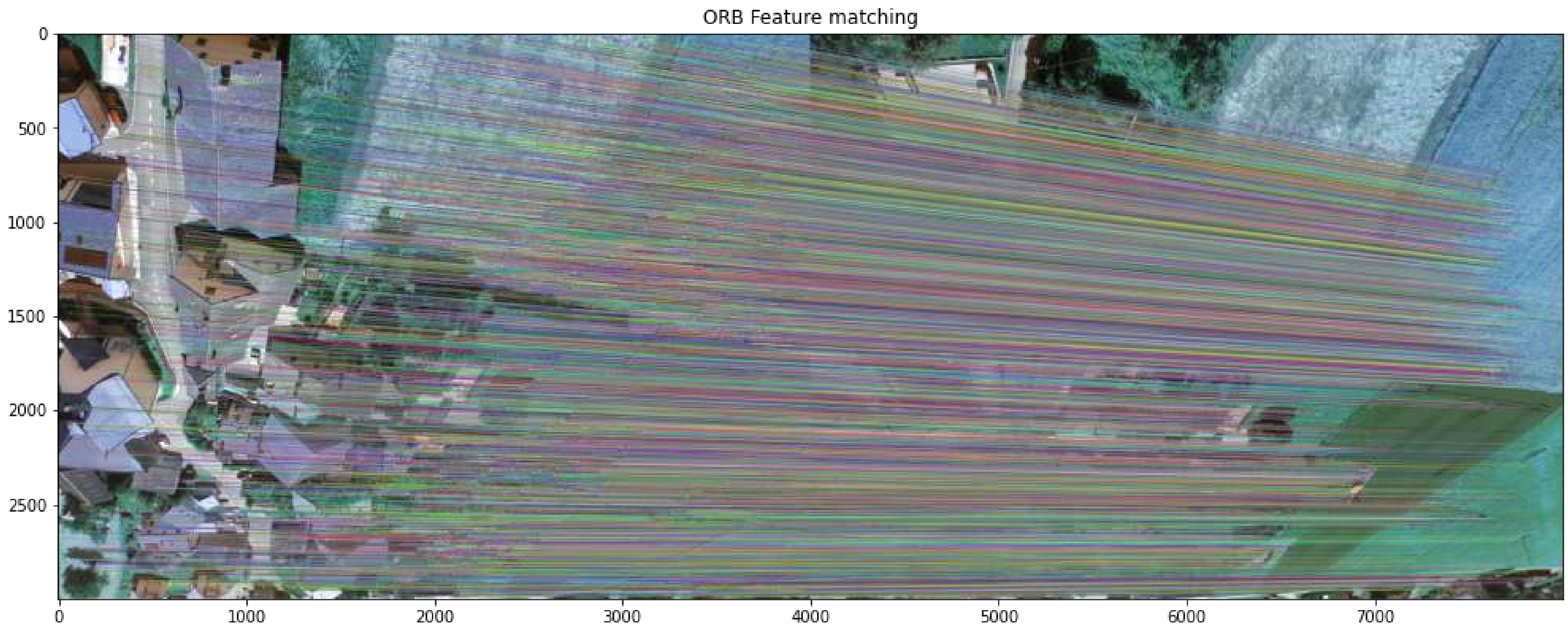
```
Number of raw matches: 185380.
```

Applying ratio test

In [41]:
```
good = [ ]
for m, n in matches:
  if m.distance < 0.7*n.distance :
    good.append([m])
matches = np.asarray(good)
```

In [42]:
```
img4 =  cv2.drawMatchesKnn(img1,kp1,img2,kp2,matches,None,flags=2)
plt.figure(figsize=(17,10))
plt.title("ORB Feature matching")
plt.imshow(img4)
```

Out[42]: <matplotlib.image.AxesImage at 0x7f3f8015f6a0>



Finding the Homography

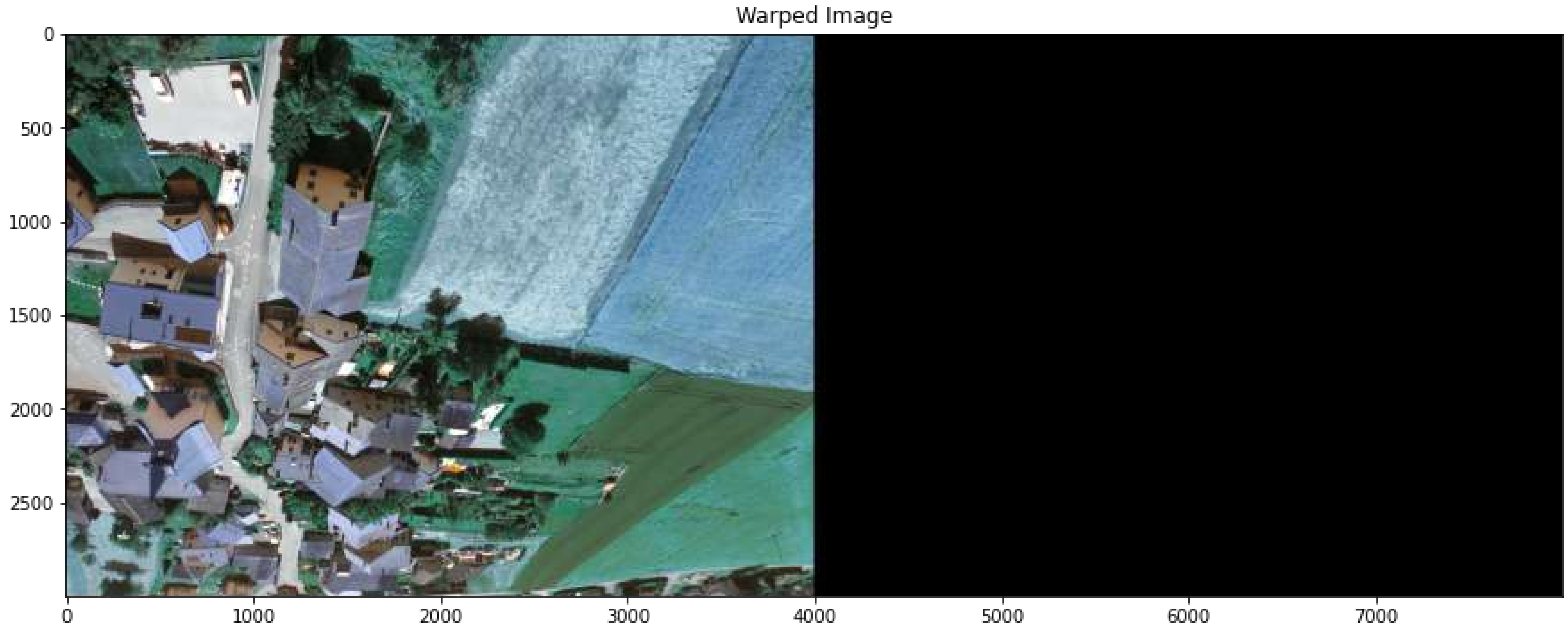
In [43]:

```
if len(matches[:,0]) >= 4:
  src = np.float32([ kp1[m.queryIdx].pt for m in matches[:,0] ]).reshape(-1,1,2)
  dst = np.float32([ kp2[m.trainIdx].pt for m in matches[:,0] ]).reshape(-1,1,2)
  H, masked = cv2.findHomography(src, dst, cv2.RANSAC, 5.0)
else:
  raise AssertionError("Can't find enough keypoints.")
```

Warping these images together

In [44]:

```
dst = cv2.warpPerspective(img1,H,(img2.shape[1] + img1.shape[1], img2.shape[0]))
dst[0:img2.shape[0], 0:img2.shape[1]] = img2
plt.figure(figsize=[15,10]),plt.title('Warped Image')
plt.imshow(dst)
plt.show()
```

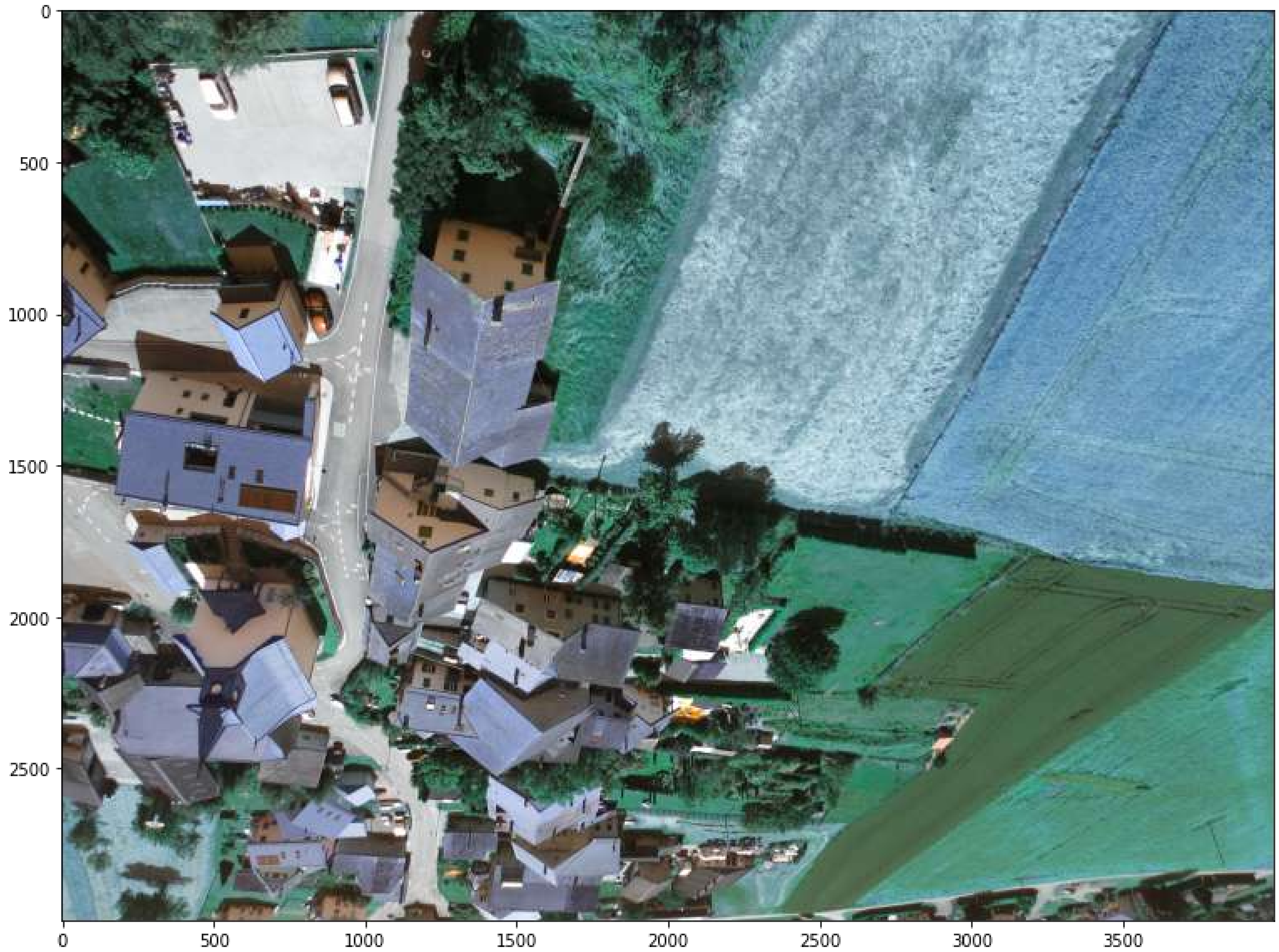


In [45]:

```
def crop(image):
  y_nonzero, x_nonzero, _ = np.nonzero(image)
  return image[np.min(y_nonzero):np.max(y_nonzero), np.min(x_nonzero):np.max(x_nonzero)]
```

In [46]:

```
plt.figure(figsize=(15,10))
plt.imshow(crop(dst), cmap='gray')
output = crop(dst)
```



After cropping the Warped images

Detecting keypoints and descriptors for the 3rd image

In [47]:

```python
sift = cv2.xfeatures2d.SIFT_create()

kp4, des4 = sift.detectAndCompute(output,None)

keypoints_with_size4 = np.copy(output)
cv2.drawKeypoints(output, kp4, keypoints_with_size4, flags=cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS)
```

Out[47]:
```
array([[[ 66,  73,  68],
        [ 54,  61,  56],
        [ 44,  55,  47],
        ...,
        [ 96, 145, 171],
        [106, 155, 181],
        [114, 162, 186]],

       [[ 59,  70,  62],
        [ 60,  71,  63],
        [ 64,  75,  67],
        ...,
        [ 99, 149, 177],
        [105, 155, 183],
        [106, 155, 181]],

       [[ 54,  65,  57],
        [ 64,  75,  67],
        [ 71,  84,  76],
        ...,
        [ 98, 150, 180],
        [ 99, 151, 181],
        [ 97, 147, 175]],

       ...,

       [[167, 189, 201],
        [166, 188, 200],
        [164, 186, 198],
        ...,
        [ 58,  56,  46],
        [ 58,  56,  46],
        [ 59,  57,  47]],

       [[165, 187, 199],
        [164, 186, 198],
```

```
 [165, 187, 199],
 ...,
 [ 59,  57,  47],
 [ 60,  58,  48],
 [ 64,  62,  52]],

[[164, 186, 198],
 [165, 187, 199],
 [167, 189, 201],
 ...,
 [ 60,  59,  49],
 [ 64,  63,  53],
 [ 69,  67,  57]]], dtype=uint8)
```

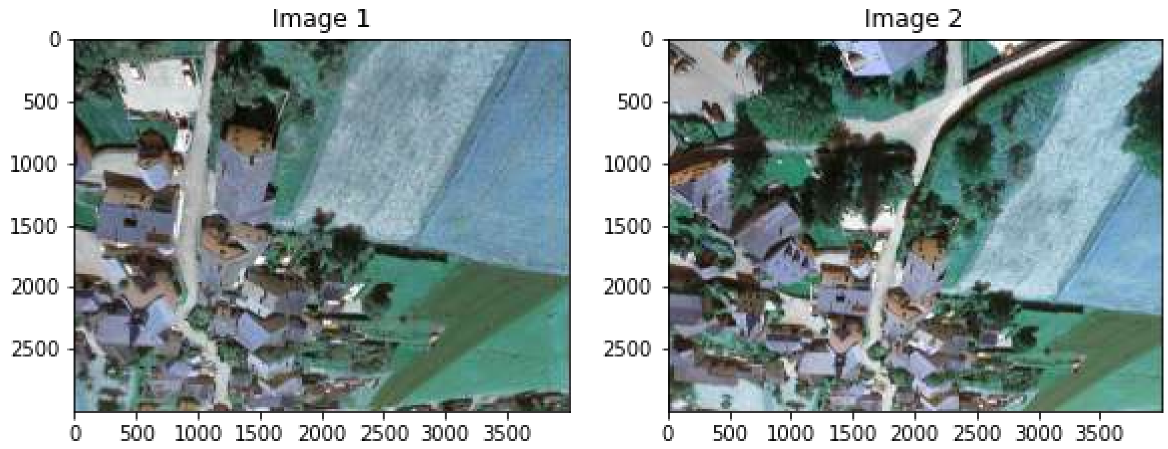
Comparing with the 3rd image

In [49]:

```
plt.figure(figsize=(15,10))
plt.subplot(1, 3, 1)
plt.title("Image 1")
plt.imshow(keypoints_with_size4, cmap='gray')
plt.subplot(1, 3, 2)
plt.title("Image 2")
plt.imshow(keypoints_with_size3, cmap='gray')
```

Out[49]:

```
<matplotlib.image.AxesImage at 0x7f3f7d5c9470>
```



In [50]:
```python
bf = cv2.BFMatcher()
matches = bf.knnMatch(des3,des4, k=2)
print("keypoints: {}, descriptors: {}".format(len(kp3), des3.shape))
print("keypoints: {}, descrlptors: {}".format(len(kp4), des4.shape))
```

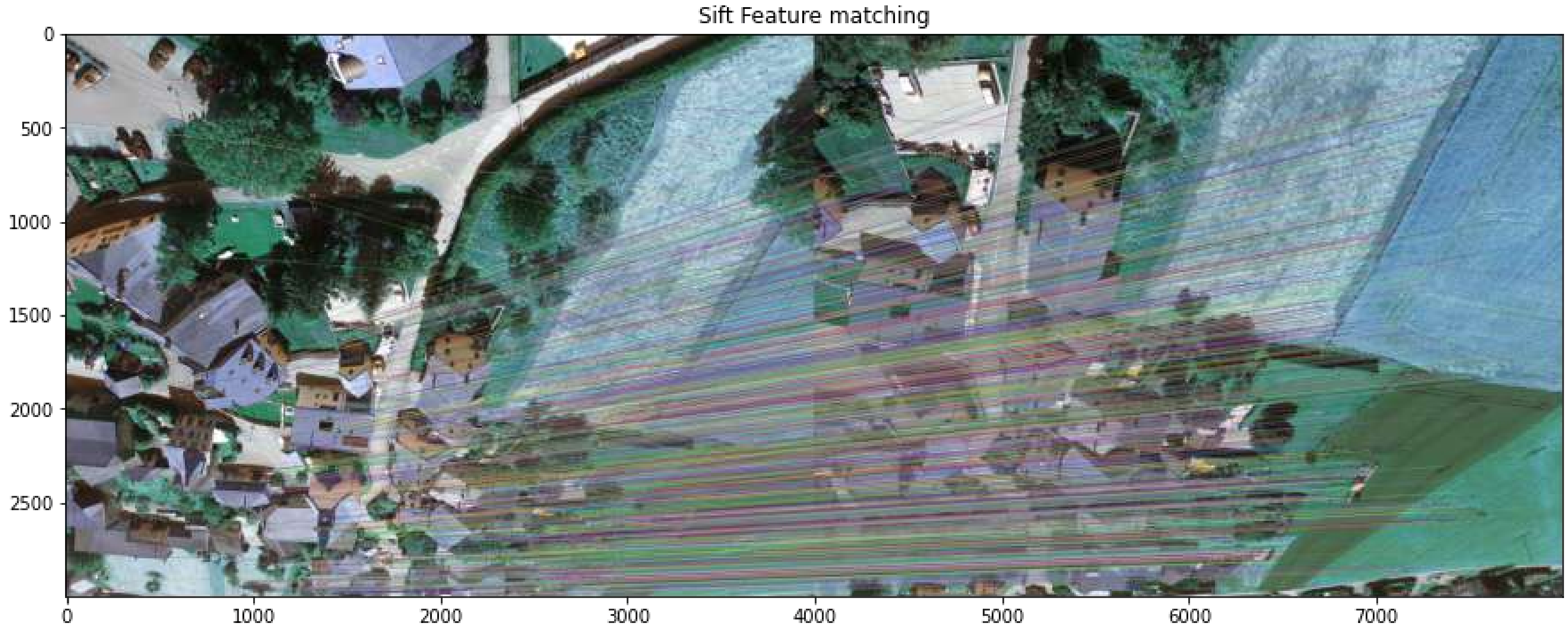
```
keypoints: 159767, descriptors: (159767, 128)
keypoints: 172032, descrlptors: (172032, 128)
```

In [52]:
```python
good = []
for m,n in matches:
  if m.distance < 0.7*n.distance:
    good.append([m])
matches = np.asarray(good)
```

SIFT Feature matching

In [53]:
```python
img5 = cv2.drawMatchesKnn(img3,kp3,output,kp4,matches,None,flags=2)
plt.figure(figsize=(15,10))
plt.title("Sift Feature matching")
plt.imshow(img5)
```

Out[53]:
```
<matplotlib.image.AxesImage at 0x7f3f7d777cf8>
```

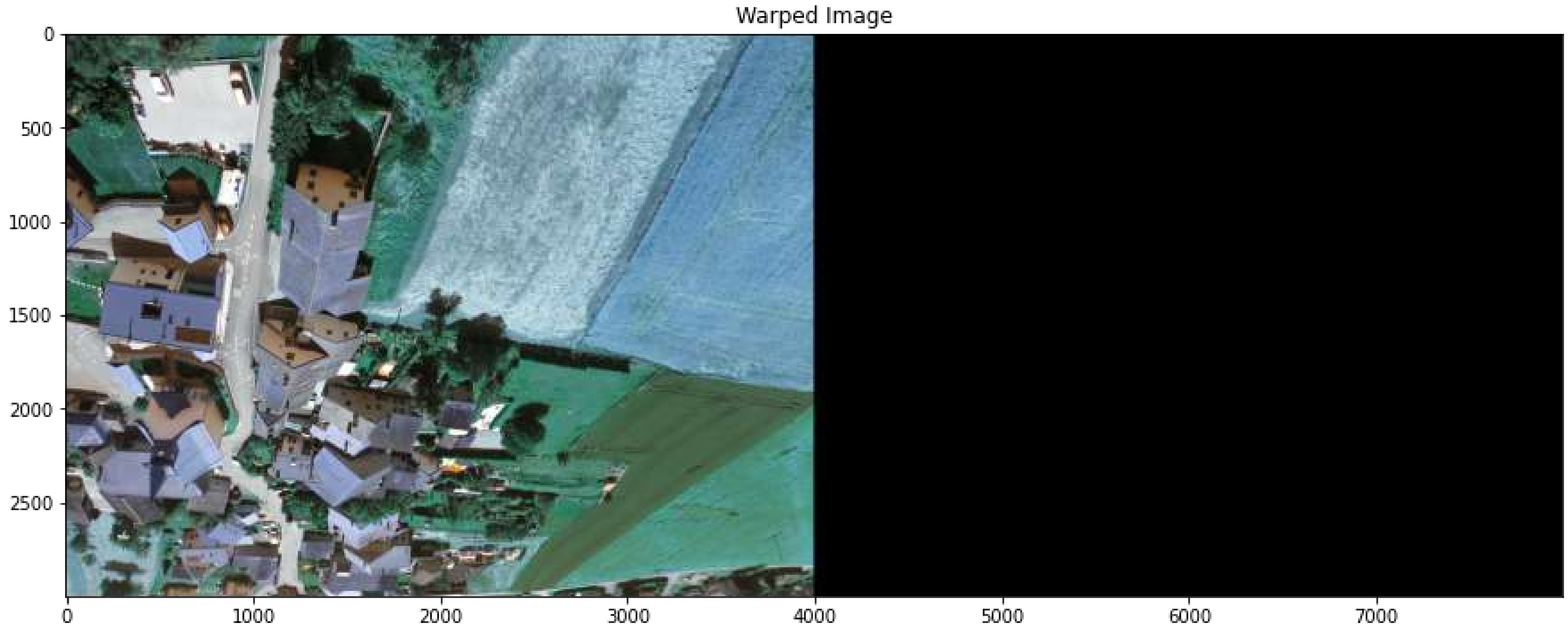


In [54]:

```
if len(matches[:,0]) >= 4:
  src = np.float32([ kp3[m.queryIdx].pt for m in matches[:,0] ]).reshape(-1,1,2)
  dst = np.float32([ kp4[m.trainIdx].pt for m in matches[:,0] ]).reshape(-1,1,2)
  H, masked = cv2.findHomography(src, dst, cv2.RANSAC, 5.0)
else:
  raise AssertionError("Can’t find enough keypoints.")
```

In [55]:

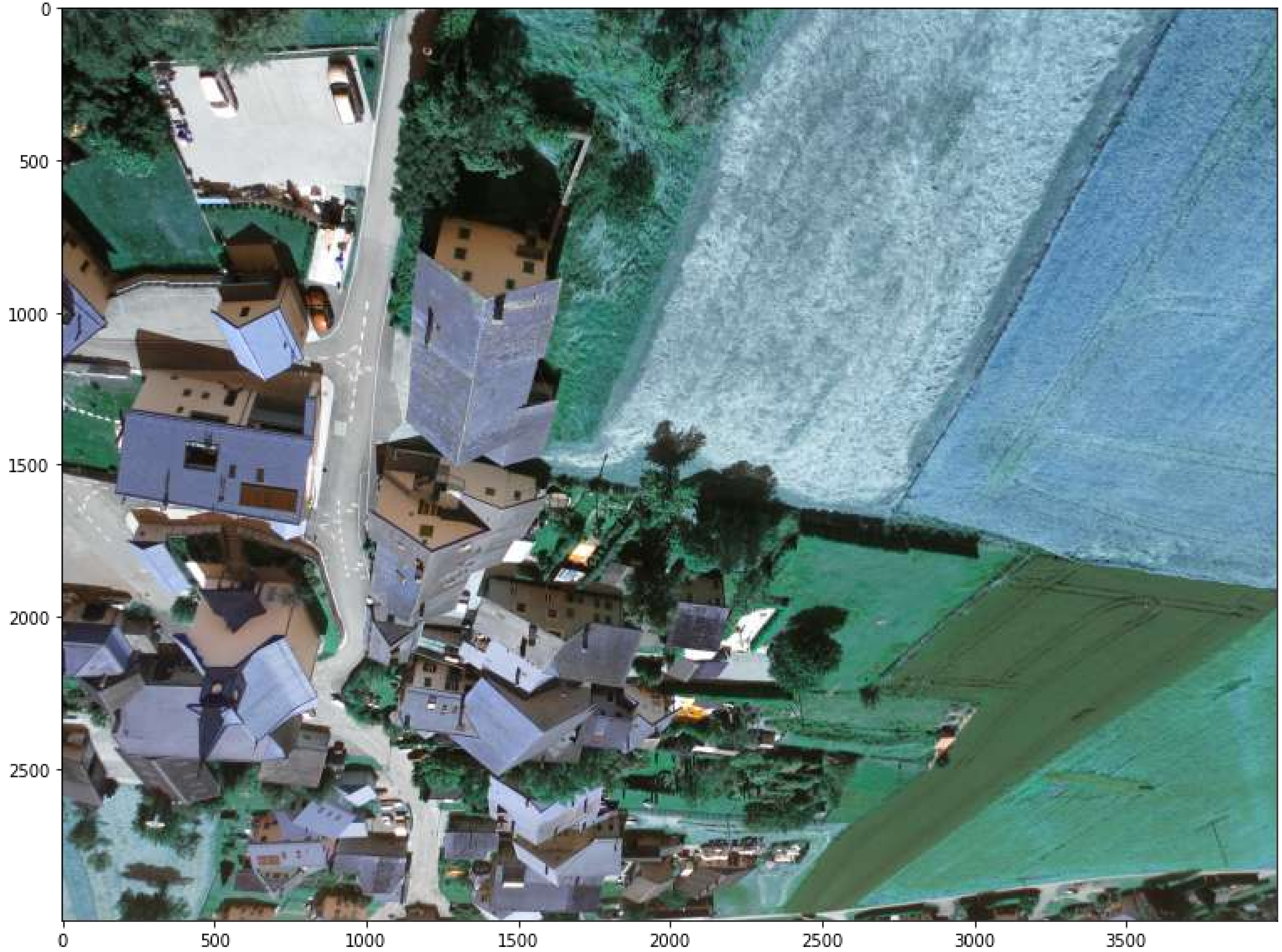
```
dst = cv2.warpPerspective(img3,H,(output.shape[1] + img3.shape[1], output.shape[0]))
dst[0:output.shape[0], 0:output.shape[1]] = output
plt.figure(figsize=[15,10]),plt.title('Warped Image')
plt.imshow(dst)
plt.show()
```



Stitched/Warped image is generated, only croping is left

In [57]:

```
plt.figure(figsize=(15,10))
plt.imshow(crop(dst), cmap='gray')
output2 = crop(dst)
```



The final image after stitching 3 images together to form an Orthomosaic

This was another successful result.

Reference:

- https://www.pyimagesearch.com/2018/12/17/image-stitching-with-opencv-and-python/

- https://medium.com/analytics-vidhya/image-stitching-with-opencv-and-python-1ebd9e0a6d78

- https://www.sensefly.com/education/datasets/

–By,

SUBHAYU ROY