General Framework of Modern Photogrammetry

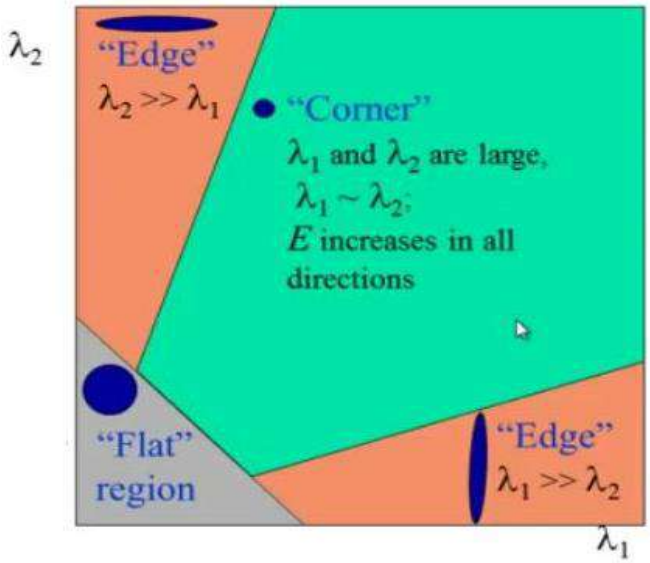
Traditional Feature Based Approaches (TFBA)

Features are parts or patterns of an object in an image that help to identify it. For example — a square has 4 corners and 4 edges, they can be called features of the square, and they help us humans identify it's a square. Features include properties like corners, edges, regions of interest points, ridges, etc.

Traditional Computer Vision techniques for feature detection include:

Harris Corner Detection

Uses a Gaussian window function to detect corners.

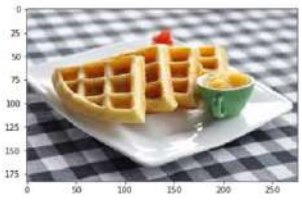


Harris Corner Detection

Import resources and display image

In [1]:
```
import matplotlib.pyplot as plt
import numpy as np
import cv2

%matplotlib inline

# Read in the image
image = cv2.imread('images/waffle.jpg')

# Make a copy of the image
image_copy = np.copy(image)

# Change color to RGB (from BGR)
image_copy = cv2.cvtColor(image_copy, cv2.COLOR_BGR2RGB)

plt.imshow(image_copy)
```

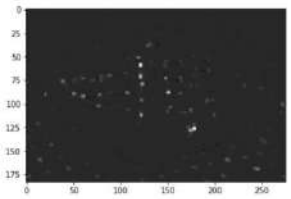
Out[1]: <matplotlib.image.AxesImage at 0x7ffb1f306eb8>



Detect corners

In [2]:
```
# Convert to grayscale
gray = cv2.cvtColor(image_copy, cv2.COLOR_RGB2GRAY)
gray = np.float32(gray)

# Detect corners
dst = cv2.cornerHarris(gray, 2, 3, 0.04)

# Dilate corner image to enhance corner points
dst = cv2.dilate(dst,None)

plt.imshow(dst, cmap='gray')
```

Out[2]: <matplotlib.image.AxesImage at 0x7ffb1f2b2828>



Extract and display strong corners

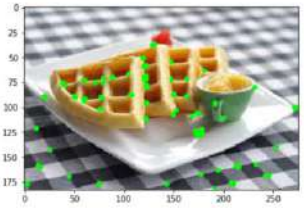
In [3]:
```
# This value vary depending on the image and how many corners you want to detect
# Try changing this free parameter, 0.1, to be larger or smaller and see what happens
thresh = 0.1*dst.max()

# Create an image copy to draw corners on
corner_image = np.copy(image_copy)
```


Extract and display strong corners

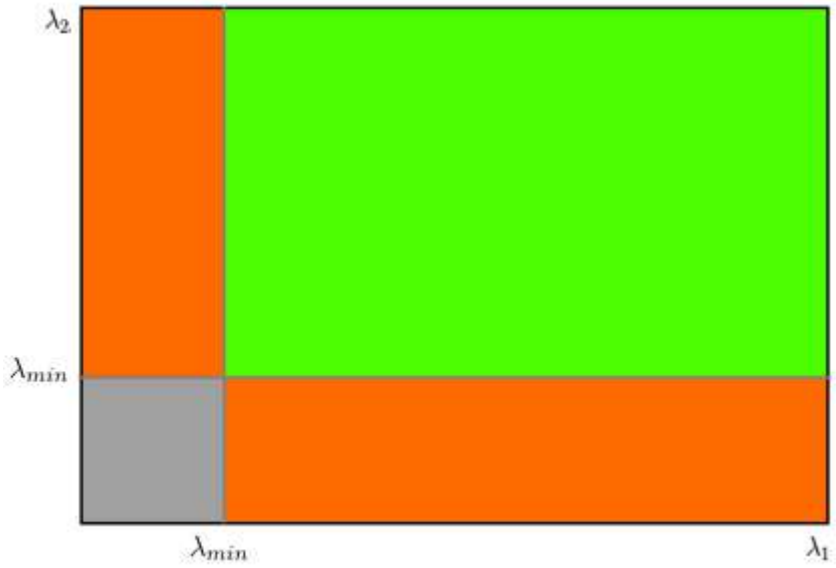
In [3]:
```
# This value vary depending on the image and how many corners you want to detect
# Try changing this free parameter, 0.1, to be larger or smaller and see what happens
thresh = 0.1*dst.max()

# Create an image copy to draw corners on
corner_image = np.copy(image_copy)
```


```
# Iterate through all the corners and draw them on the image (if they pass the threshold)
for j in range(0, dst.shape[0]):
    for i in range(0, dst.shape[1]):
        if(dst[j,i] > thresh):
            # image, center pt, radius, color, thickness
            cv2.circle( corner_image, (i, j), 1, (0,255,0), 1)

plt.imshow(corner_image)
```

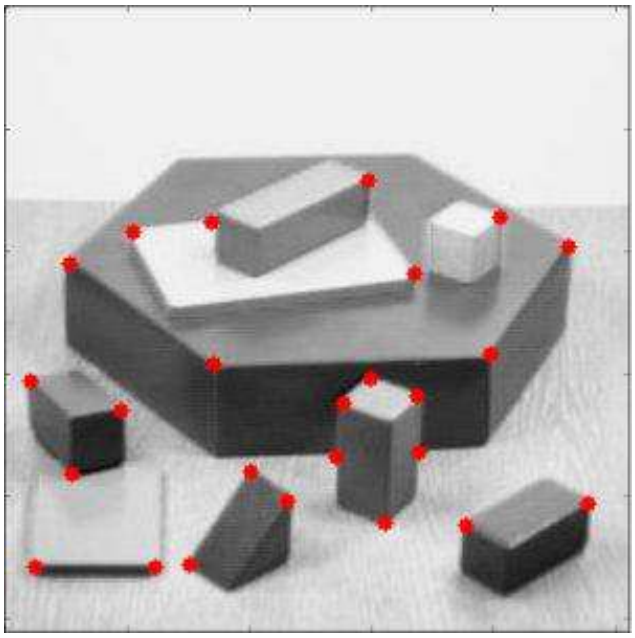
Out[3]: <matplotlib.image.AxesImage at 0x7ffae044cac8>



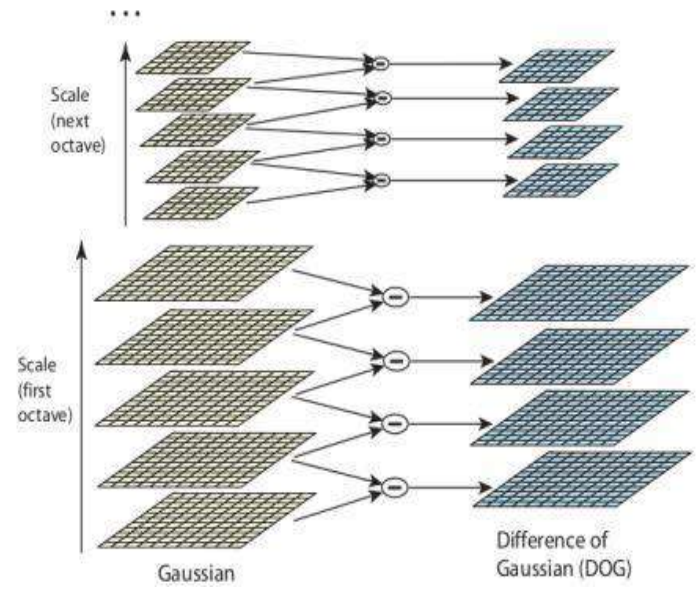
Shi-Tomasi Corner Detector

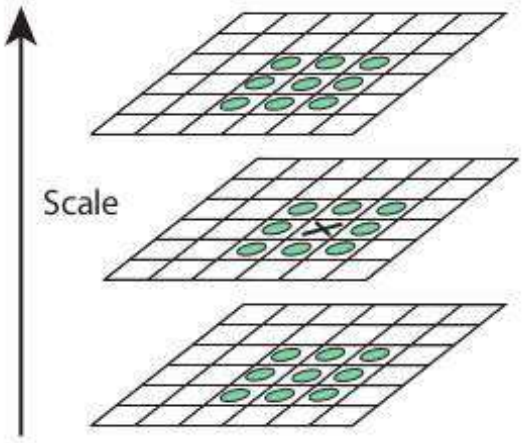


The authors modified the scoring function used in Harris Corner Detection to achieve a better corner detection technique

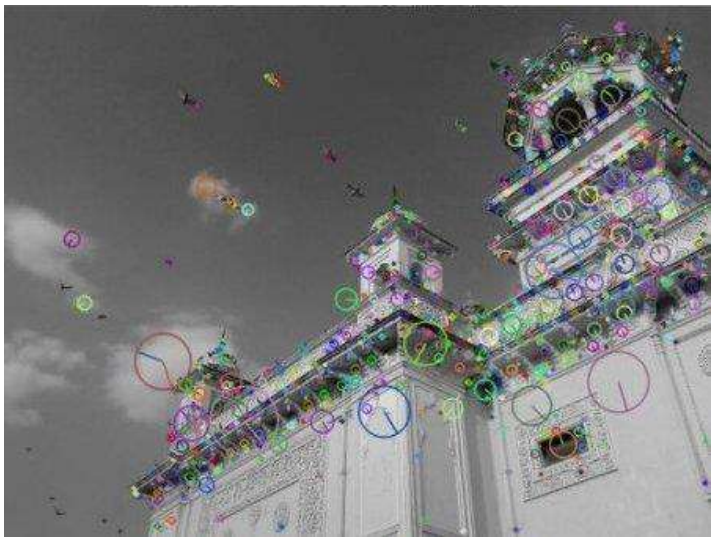


Scale-Invariant Feature Transform (SIFT)

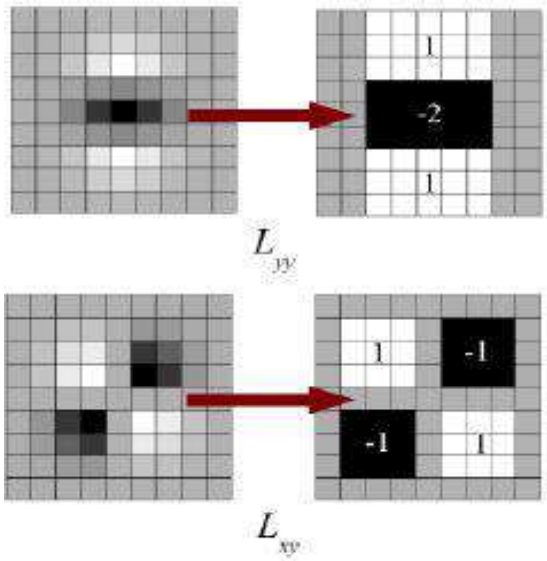




This technique is scale invariant unlike the previous two.



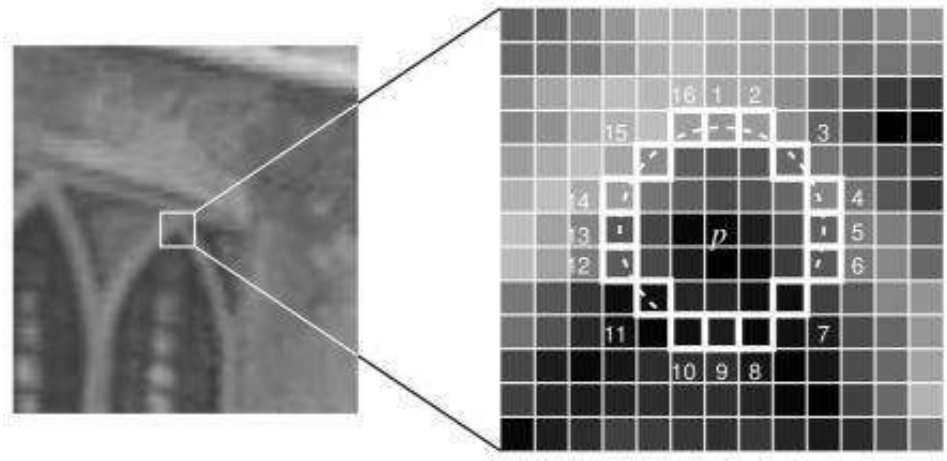
Speeded-Up Robust Features (SURF)



This is a faster version of SIFT as the name says.

Features from Accelerated Segment Test (FAST)

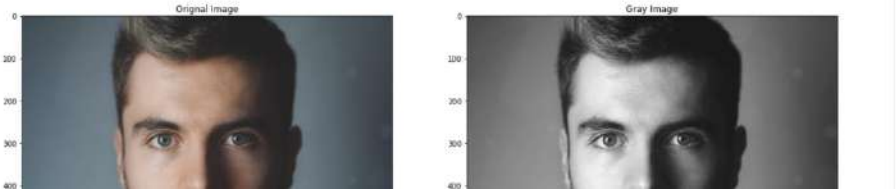
This is a much more faster corner detection technique compared to SURF.



Introduction to FAST (Features from Accelerated Segment Test)

In [1]:
```
import cv2
import matplotlib.pyplot as plt
import numpy as np
%matplotlib inline

# Load the image
image1 = cv2.imread('./images/face1.jpeg')

# Convert image to RGB
image = cv2.cvtColor(image1, cv2.COLOR_BGR2RGB)

# Convert image to gray scale
gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY)

# Display image and gray image
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("Orignal Image")
plots[0].imshow(image)

plots[1].set_title("Gray Image")
plots[1].imshow(gray, cmap="gray")
```

Out[1]: `<matplotlib.figure.AxesImage at 0x7f0e89fca860>`

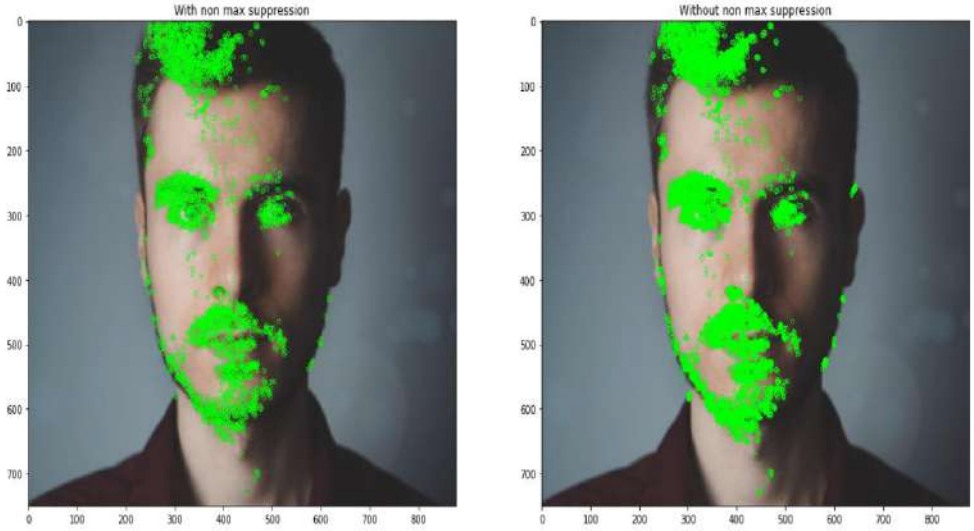


In [2]:
```
fast = cv2.FastFeatureDetector_create()

# Detect keypoints with non max suppression
keypoints_with_nonmax = fast.detect(gray, None)

# Disable nonmaxSuppression
fast.setNonmaxSuppression(False)

# Detect keypoints without non max suppression
keypoints_without_nonmax = fast.detect(gray, None)

image_with_nonmax = np.copy(image)
image_without_nonmax = np.copy(image)

# Draw keypoints on top of the input image
cv2.drawKeypoints(image, keypoints_with_nonmax, image_with_nonmax, color=(0,255,0), flags=cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS)
cv2.drawKeypoints(image, keypoints_without_nonmax, image_without_nonmax, color=(0,255,0), flags=cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINT
S)

# Display image with and without non max suppression
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("With non max suppression")
plots[0].imshow(image_with_nonmax)

plots[1].set_title("Without non max suppression")
plots[1].imshow(image_without_nonmax)

# Print the number of keypoints detected in the training image
print("Number of Keypoints Detected In The Image With Non Max Suppression: ", len(keypoints_with_nonmax))

# Print the number of keypoints detected in the query image
print("Number of Keypoints Detected In The Image Without Non Max Suppression: ", len(keypoints_without_nonmax))
```

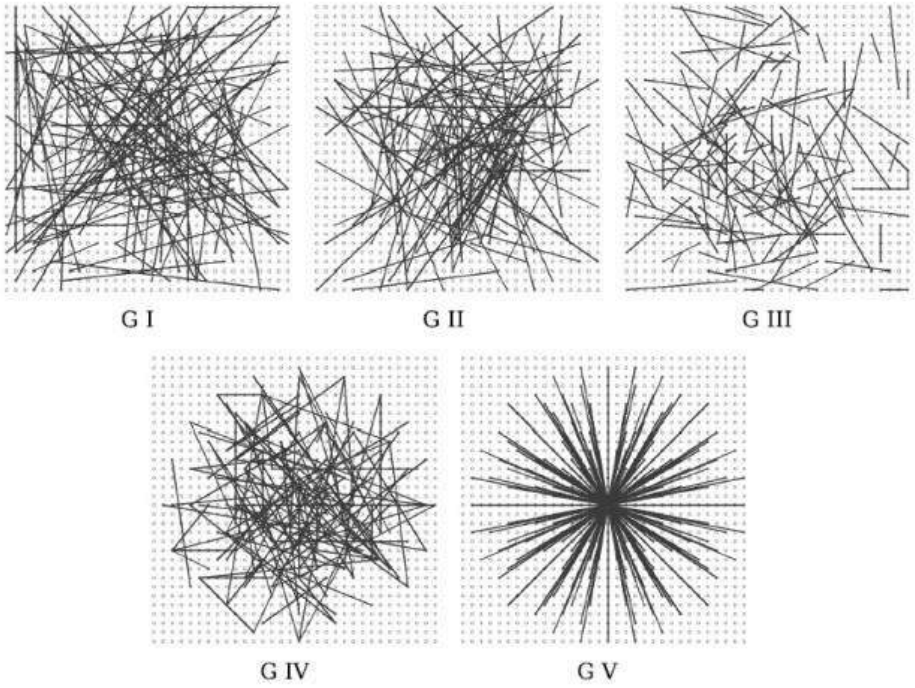
```
Number of Keypoints Detected In The Image With Non Max Suppression:  2354
Number of Keypoints Detected In The Image Without Non Max Suppression:  6330
```

```
# Print the number of keypoints detected in the query image
print("Number of Keypoints Detected In The Image Without Non Max Suppression: ", len(keypoints_without_nonmax))
```

```
Number of Keypoints Detected In The Image With Non Max Suppression:  2354
Number of Keypoints Detected In The Image Without Non Max Suppression:  6330
```



Binary Robust Independent Elementary Features (BRIEF)



BRIEF(Binary Robust Independent Elementary Features)

Import resources and display image

In [1]:
```
import cv2
import matplotlib.pyplot as plt
import numpy as np
%matplotlib inline

# Load the image
image1 = cv2.imread('./images/face1.jpeg')

# Convert the training image to RGB
training_image = cv2.cvtColor(image1, cv2.COLOR_BGR2RGB)

# Convert the training image to gray scale
training_gray = cv2.cvtColor(training_image, cv2.COLOR_RGB2GRAY)

# Create test image by adding Scale Invariance and Rotational Invariance
test_image = cv2.pyrDown(training_image)
test_image = cv2.pyrDown(test_image)
num_rows, num_cols = test_image.shape[:2]

rotation_matrix = cv2.getRotationMatrix2D((num_cols/2, num_rows/2), 30, 1)
test_image = cv2.warpAffine(test_image, rotation_matrix, (num_cols, num_rows))

test_gray = cv2.cvtColor(test_image, cv2.COLOR_RGB2GRAY)

# Display traning image and testing image
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("Training Image")
plots[0].imshow(training_image)

plots[1].set_title("Testing Image")
plots[1].imshow(test_image)
```

Out[1]:
```
<matplotlib.image.AxesImage at 0x7fbb10abd710>
```

```
plots[1].imshow(test_image)
```

Out[1]: <matplotlib.image.AxesImage at 0x7fbb10abd710>

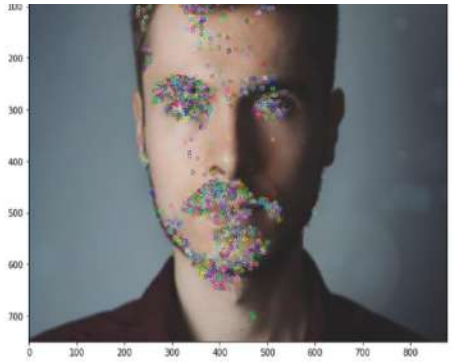
Detect keypoints and Create Descriptor

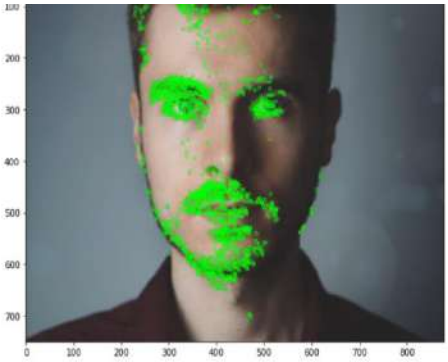
In [2]:
```
fast = cv2.FastFeatureDetector_create()
brief = cv2.xfeatures2d.BriefDescriptorExtractor_create()

train_keypoints = fast.detect(training_gray, None)
test_keypoints = fast.detect(test_gray, None)

train_keypoints, train_descriptor = brief.compute(training_gray, train_keypoints)
test_keypoints, test_descriptor = brief.compute(test_gray, test_keypoints)
```

Detect keypoints and Create Descriptor

In [2]:
```
fast = cv2.FastFeatureDetector_create()
brief = cv2.xfeatures2d.BriefDescriptorExtractor_create()

train_keypoints = fast.detect(training_gray, None)
test_keypoints = fast.detect(test_gray, None)

train_keypoints, train_descriptor = brief.compute(training_gray, train_keypoints)
test_keypoints, test_descriptor = brief.compute(test_gray, test_keypoints)

keypoints_without_size = np.copy(training_image)
keypoints_with_size = np.copy(training_image)

cv2.drawKeypoints(training_image, train_keypoints, keypoints_without_size, color = (0, 255, 0))

cv2.drawKeypoints(training_image, train_keypoints, keypoints_with_size, flags = cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS)

# Display image with and without keypoints size
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("Train keypoints With Size")
plots[0].imshow(keypoints_with_size, cmap='gray')

plots[1].set_title("Train keypoints Without Size")
plots[1].imshow(keypoints_without_size, cmap='gray')

# Print the number of keypoints detected in the training image
print("Number of Keypoints Detected In The Training Image: ", len(train_keypoints))

# Print the number of keypoints detected in the query image
print("Number of Keypoints Detected In The Query Image: ", len(test_keypoints))
```

```
Number of Keypoints Detected In The Training Image:  2203
Number of Keypoints Detected In The Query Image:  137
```





Matching Keypoints

In [3]:
```
# Create a Brute Force Matcher object.
bf = cv2.BFMatcher(cv2.NORM_HAMMING, crossCheck = True)

# Perform the matching between the BRIEF descriptors of the training image and the test image
matches = bf.match(train_descriptor, test_descriptor)

# The matches with shorter distance are the ones we want.
matches = sorted(matches, key = lambda x : x.distance)

result = cv2.drawMatches(training_image, train_keypoints, test_gray, test_keypoints, matches, test_gray, flags = 2)

# Display the best matching points
plt.rcParams['figure.figsize'] = [14.0, 7.0]
plt.title('Best Matching Points')
plt.imshow(result)
```

Matching Keypoints

In [3]:
```
# Create a Brute Force Matcher object.
bf = cv2.BFMatcher(cv2.NORM_HAMMING, crossCheck = True)

# Perform the matching between the BRIEF descriptors of the training image and the test image
matches = bf.match(train_descriptor, test_descriptor)

# The matches with shorter distance are the ones we want.
matches = sorted(matches, key = lambda x : x.distance)

result = cv2.drawMatches(training_image, train_keypoints, test_gray, test_keypoints, matches, test_gray, flags = 2)

# Display the best matching points
plt.rcParams['figure.figsize'] = [14.0, 7.0]
plt.title('Best Matching Points')
plt.imshow(result)
plt.show()

# Print total number of matching points between the training and query images
print("\nNumber of Matching Keypoints Between The Training and Query Images: ", len(matches))
```

Oriented FAST and Rotated BRIEF (ORB)

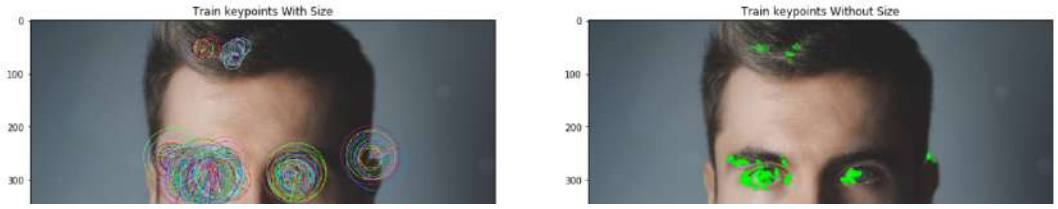
In [1]:
```
import cv2
import matplotlib.pyplot as plt
import numpy as np
%matplotlib inline

# Load the image
image1 = cv2.imread('./images/face1.jpeg')

# Convert the training image to RGB
training_image = cv2.cvtColor(image1, cv2.COLOR_BGR2RGB)

# Convert the training image to gray scale
training_gray = cv2.cvtColor(training_image, cv2.COLOR_RGB2GRAY)

# Create test image by adding Scale Invariance and Rotational Invariance
test_image = cv2.pyrDown(training_image)
test_image = cv2.pyrDown(test_image)
num_rows, num_cols = test_image.shape[:2]

rotation_matrix = cv2.getRotationMatrix2D((num_cols/2, num_rows/2), 30, 1)
test_image = cv2.warpAffine(test_image, rotation_matrix, (num_cols, num_rows))

test_gray = cv2.cvtColor(test_image, cv2.COLOR_RGB2GRAY)

# Display traning image and testing image
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("Training Image")
plots[0].imshow(training_image)

plots[1].set_title("Testing Image")
plots[1].imshow(test_image)
```

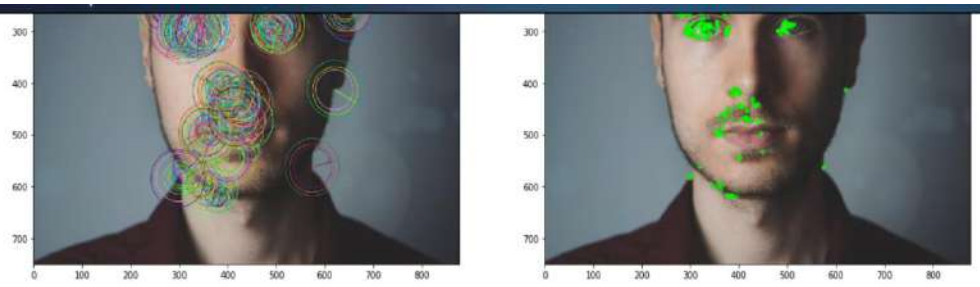
Out[1]: <matplotlib.image.AxesImage at 0x7fa06a921d30>

In [2]:
```
orb = cv2.ORB_create()

train_keypoints, train_descriptor = orb.detectAndCompute(training_gray, None)
test_keypoints, test_descriptor = orb.detectAndCompute(test_gray, None)

keypoints_without_size = np.copy(training_image)
keypoints_with_size = np.copy(training_image)

cv2.drawKeypoints(training_image, train_keypoints, keypoints_without_size, color = (0, 255, 0))

cv2.drawKeypoints(training_image, train_keypoints, keypoints_with_size, flags = cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS)

# Display image with and without keypoints size
```

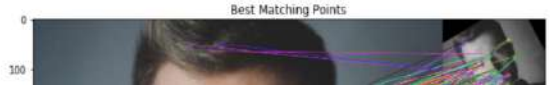
In [2]:
```
orb = cv2.ORB_create()

train_keypoints, train_descriptor = orb.detectAndCompute(training_gray, None)
test_keypoints, test_descriptor = orb.detectAndCompute(test_gray, None)

keypoints_without_size = np.copy(training_image)
keypoints_with_size = np.copy(training_image)

cv2.drawKeypoints(training_image, train_keypoints, keypoints_without_size, color = (0, 255, 0))

cv2.drawKeypoints(training_image, train_keypoints, keypoints_with_size, flags = cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS)

# Display image with and without keypoints size
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("Train keypoints With Size")
plots[0].imshow(keypoints_with_size, cmap='gray')

plots[1].set_title("Train keypoints Without Size")
plots[1].imshow(keypoints_without_size, cmap='gray')

# Print the number of keypoints detected in the training image
print("Number of Keypoints Detected In The Training Image: ", len(train_keypoints))

# Print the number of keypoints detected in the query image
print("Number of Keypoints Detected In The Query Image: ", len(test_keypoints))
```

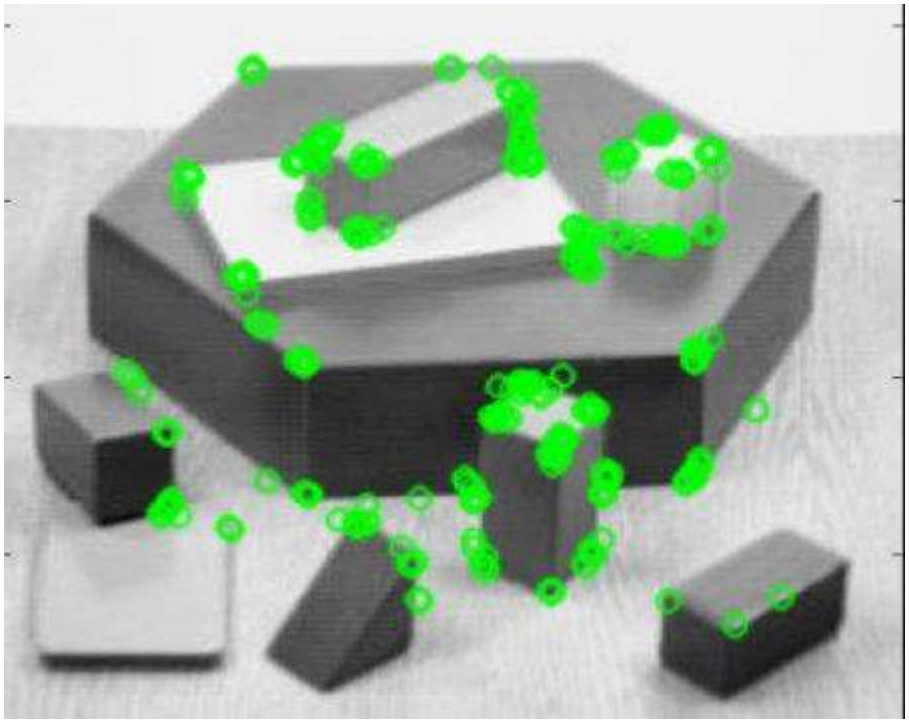
```
Number of Keypoints Detected In The Training Image:  500
Number of Keypoints Detected In The Query Image:  176
```





In [3]:
```
# Create a Brute Force Matcher object.
bf = cv2.BFMatcher(cv2.NORM_HAMMING, crossCheck = True)

# Perform the matching between the ORB descriptors of the training image and the test image
matches = bf.match(train_descriptor, test_descriptor)

# The matches with shorter distance are the ones we want.
matches = sorted(matches, key = lambda x : x.distance)

result = cv2.drawMatches(training_image, train_keypoints, test_gray, test_keypoints, matches, test_gray, flags = 2)

# Display the best matching points
plt.rcParams['figure.figsize'] = [14.0, 7.0]
plt.title('Best Matching Points')
plt.imshow(result)
plt.show()

# Print total number of matching points between the training and query images
print("\nNumber of Matching Keypoints Between The Training and Query Images: ", len(matches))
```





Importing all the packages

```
from IPython.display import Image, display
import numpy as np
from os.path import join
import pandas as pd
import tensorflow as tf
import matplotlib.pyplot as plt
```

```
df_org = pd.read_csv('/content/datasets.csv')

df_org.head()
```

	Dataset	Camera	Category	Author	Organisation/Project	
0	AvignonHotelDesMonnaies	Canon EOS 5D Mark II	Building	Romuald Perrot rperrot	NaN	https://github.com/r
1	BoutevilleWindowDetail	Canon EOS 5D Mark II	Building	Romuald Perrot rperrot	NaN	https://github.com/r
2	BurgosPuertaDeLaCoroneria	Canon EOS 5D Mark II	Building	Romuald Perrot rperrot	NaN	https://github.com/r
3	CognacGardenBuilding	Canon EOS 5D Mark II	Building	Romuald Perrot rperrot	NaN	https://github.com/r
4	CognacStJacquesDoor	Canon EOS 5D Mark II	Building	Romuald Perrot rperrot	NaN	https://github.com/r

```
df_org.shape
```

```
(356, 17)
```

```
df = df_org.copy()
df = df.dropna(axis=0, subset=['Source'])
df.head()
```

	Dataset	Camera	Category	Author	Organisation/Project	
0	AvignonHotelDesMonnaies	Canon EOS 5D Mark II	Building	Romuald Perrot rperrot	NaN	https://github.com/r
1	BoutevilleWindowDetail	Canon EOS 5D Mark II	Building	Romuald Perrot rperrot	NaN	https://github.com/r
2	BurgosPuertaDeLaCoroneria	Canon EOS 5D Mark II	Building	Romuald Perrot rperrot	NaN	https://github.com/r
3	CognacGardenBuilding	Canon EOS 5D Mark II	Building	Romuald Perrot rperrot	NaN	https://github.com/r
		Canon EOS		Romuald		

```
df.shape
```

```
(338, 17)
```

```
df.describe()
```

	Images
count	117.000000
mean	1483.555556
std	12585.427620
min	3.000000
25%	25.000000
50%	120.000000
75%	165.000000
max	135660.000000

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 338 entries, 0 to 339
Data columns (total 17 columns):
 #   Column                Non-Null Count  Dtype 
---  ------                --------------  ----- 
 0   Dataset               338 non-null    object
 1   Camera                120 non-null    object
 2   Category              160 non-null    object
 3   Author                233 non-null    object
```

```
 4   Organisation/Project  152 non-null    object
 5   Source                338 non-null    object
 6   Dataset link          210 non-null    object
 7   Images                117 non-null    float64
 8   Size in GB (est.)     111 non-null    object
 9   Ground Truth          48 non-null     object
 10  License               196 non-null    object
 11  License link          133 non-null    object
 12  SampleImage           23 non-null     object
 13  Image Format          78 non-null     object
 14  DOI                   55 non-null     object
 15  Masks                 81 non-null     object
 16  Description           119 non-null    object
dtypes: float64(1), object(16)
memory usage: 47.5+ KB
```

```
import seaborn as sns
plt.figure(figsize=(12,8))
sns.pairplot(df, hue = 'Source')
```

```
/usr/local/lib/python3.6/dist-packages/seaborn/distributions.py:305: UserWarning: Dataset has
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```

```
import requests
from io import BytesIO
from PIL import Image

for i in range(100):
  r = requests.get(df['Source'][i])
  print("Status:", r.status_code)
  print(r.url)
```

```
Status: 200
https://github.com/rperrot/ReconstructionDataSet
Status: 200
https://github.com/rperrot/ReconstructionDataSet
Status: 200
https://github.com/rperrot/ReconstructionDataSet
Status: 200
https://github.com/rperrot/ReconstructionDataSet
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https://github.com/rperrot/ReconstructionDataSet
Status: 200
https://github.com/rperrot/ReconstructionDataSet
Status: 200
```

https://github.com/natowi/dataset_flowerpot
Status: 200
https://github.com/alicevision/dataset_monstree
Status: 200
https://github.com/alicevision/dataset_monstree
Status: 200
https://github.com/alicevision/dataset_monstree
Status: 200
https://github.com/alicevision/dataset_buddha
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https://peterfalkingham.com/resources/
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Status: 200

```
Source_df = df.filter(['Dataset', 'Author', 'Category','Source', 'Dataset link', 'DOI', 'Description
Source_df.head()
```

	Dataset	Author	Category	Source	
0	AvignonHotelDesMonnaies	Romuald Perrot rperrot	Building	https://github.com/rperrot/ReconstructionDataSet	https

Working on Aerial Dataset

```
get_ipython().system_raw("unrar x Village_Dataset.rar")
```

List of all images

```
import os
list = os.listdir('/content/Village_Dataset/geotagged-images')
for i in range(len(list)):
  print(list[i])
```

```
IMG_7727.JPG
IMG_7752.JPG
IMG_7750.JPG
IMG_7741.JPG
IMG_7721.JPG
IMG_7731.JPG
IMG_7743.JPG
IMG_7732.JPG
IMG_7755.JPG
IMG_7754.JPG
IMG_7737.JPG
IMG_7724.JPG
IMG_7722.JPG
IMG_7738.JPG
IMG_7729.JPG
IMG_7728.JPG
IMG_7746.JPG
IMG_7726.JPG
IMG_7749.JPG
IMG_7745.JPG
IMG_7739.JPG
IMG_7720.JPG
IMG_7733.JPG
IMG_7734.JPG
IMG_7740.JPG
IMG_7719.JPG
IMG_7748.JPG
IMG_7723.JPG
IMG_7725.JPG
IMG_7730.JPG
IMG_7742.JPG
IMG_7744.JPG
IMG_7736.JPG
IMG_7735.JPG
IMG_7747.JPG
IMG_7751.JPG
IMG_7753.JPG
```

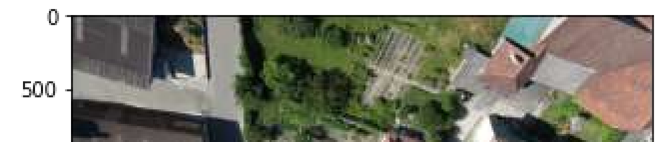
Displaying all the images available in the aerial dataset

```
import matplotlib.pyplot as plt
import matplotlib.image as mpimg

def process(filename):
    image = mpimg.imread('/content/Village_Dataset/geotagged-images/'+filename)
    plt.figure()
    plt.imshow(image)

for file in list:
    process(file)
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:6: RuntimeWarning: More than 20 f
```



0
500
1000
1500
2000
2500
3000
3500


0
500
1000
1500
2000
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3000
3500


0
500
1000
1500
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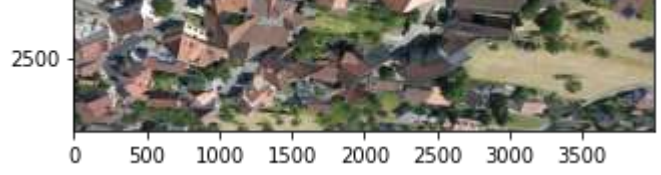
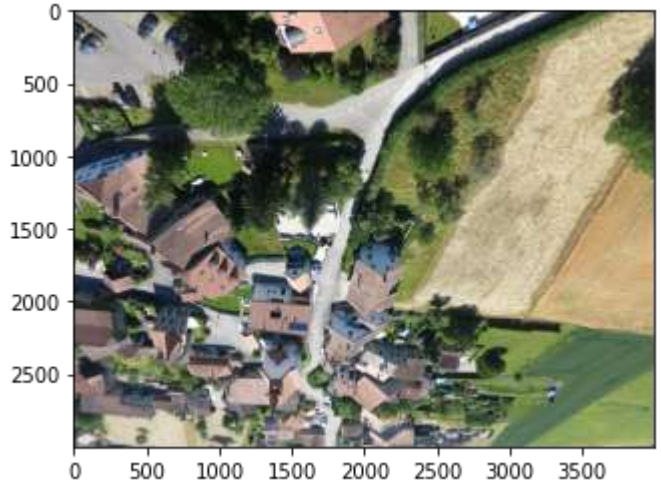
2000
2500
3000
3500


0
500
1000
1500
2000
2500
3000
3500


0
500
1000
1500
2000


0
500
1000
1500
2000
2500
3000
3500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2500
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3500


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1000
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2000
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3500


0
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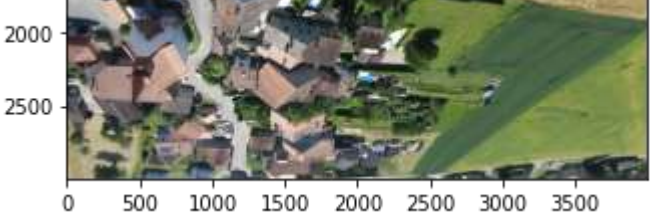
1500


0
500
1000
1500
2000
2500
3000
3500


0
500
1000
1500
2000
2500
3000
3500


0
500
1000
1500
2000
2500
3000
3500


0
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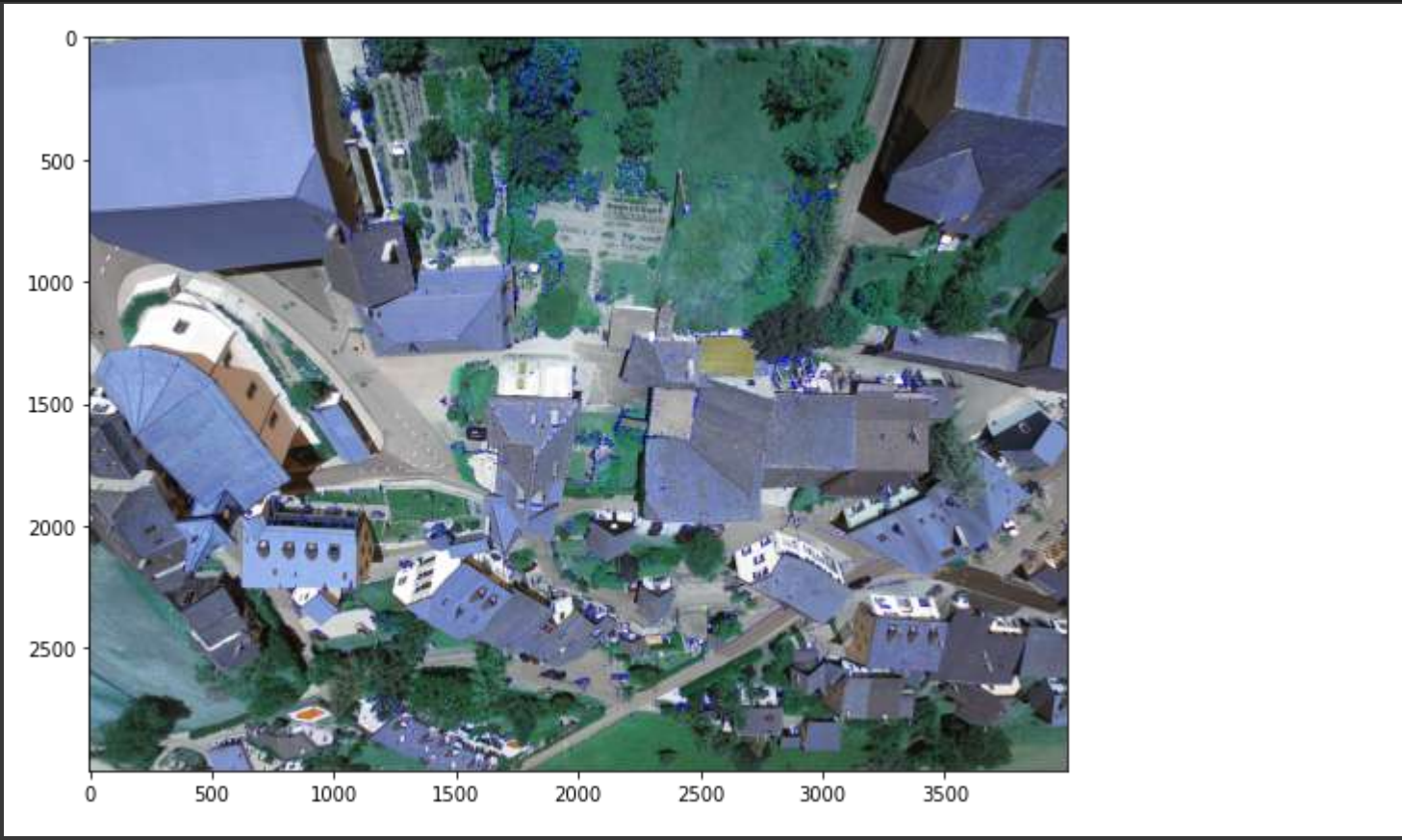
1000
1500
2000
2500
3000
3500


0
500
1000
1500
2000
2500
3000
3500

Harris Corner Detection

Harris Corner Detector in OpenCV

```
import numpy as np
import cv2 as cv
import matplotlib.pyplot as plt

filename = '/content/Village_Dataset/geotagged-images/IMG_7753.JPG'
img = cv.imread(filename)
gray = cv.cvtColor(img,cv.COLOR_BGR2GRAY)
gray = np.float32(gray)
dst = cv.cornerHarris(gray,2,3,0.04)
#result is dilated for marking the corners, not important
dst = cv.dilate(dst,None)
# Threshold for an optimal value, it may vary depending on the image.
img[dst>0.01*dst.max()]=[0,0,255]
plt.imshow(img)
if cv.waitKey(0) & 0xff == 27:
    cv.destroyAllWindows()
```



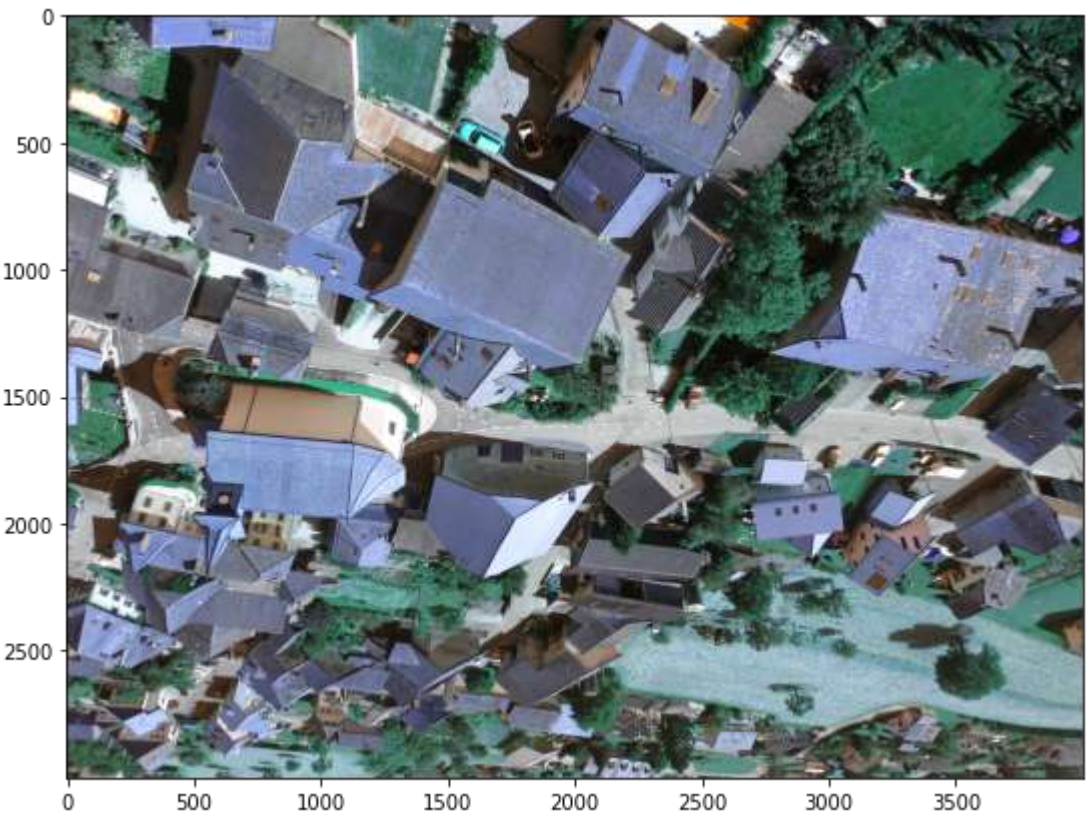
Corner with SubPixel Accuracy

```
import numpy as np
import cv2 as cv
import matplotlib.pyplot as plt

filename = '/content/Village_Dataset/geotagged-images/IMG_7736.JPG'
img = cv.imread(filename)
gray = cv.cvtColor(img,cv.COLOR_BGR2GRAY)
# find Harris corners
gray = np.float32(gray)
dst = cv.cornerHarris(gray,2,3,0.04)
dst = cv.dilate(dst,None)
ret, dst = cv.threshold(dst,0.01*dst.max(),255,0)
dst = np.uint8(dst)
# find centroids
ret, labels, stats, centroids = cv.connectedComponentsWithStats(dst)
# define the criteria to stop and refine the corners
criteria = (cv.TERM_CRITERIA_EPS + cv.TERM_CRITERIA_MAX_ITER, 100, 0.001)
corners = cv.cornerSubPix(gray,np.float32(centroids),(5,5),(-1,-1),criteria)
# Now draw them
res = np.hstack((centroids,corners))
res = np.int0(res)
img[res[:,1],res[:,0]]=[0,0,255]
img[res[:,3],res[:,2]] = [0,255,0]
cv.imwrite('subpixel5.png',img)
plt.imshow(img)
```

```
<matplotlib.image.AxesImage at 0x7fcbe6e44160>
```

Shi-Tomasi Corner Detector

```
import numpy as np
import cv2 as cv
from matplotlib import pyplot as plt

img = cv.imread('/content/Village_Dataset/geotagged-images/IMG_7725.JPG')
gray = cv.cvtColor(img,cv.COLOR_BGR2GRAY)
corners = cv.goodFeaturesToTrack(gray,25,0.01,10)
corners = np.int0(corners)
for i in corners:
    x,y = i.ravel()
    cv.circle(img,(x,y),3,255,-1)
plt.imshow(img),plt.show()
```




```
(<matplotlib.image.AxesImage at 0x7fcbe72b2240>, None)
```

Scale-Invariant Feature Transform (SIFT)

```
!pip uninstall opencv-python==4.1.2 -y
!pip uninstall opencv-contrib-python==4.1.2 -y
```

```
  Uninstalling opencv-python-4.1.2.30:
    Successfully uninstalled opencv-python-4.1.2.30
  Uninstalling opencv-contrib-python-4.1.2.30:
    Successfully uninstalled opencv-contrib-python-4.1.2.30
```

```
!pip install opencv-python
!pip install opencv-contrib-python
# !pip install opencv-python==3.3.0.10 &> /dev/null
# !pip opencv-contrib-python==3.3.0.10 &> /dev/null
```

```
  Collecting opencv-python
    Downloading https://files.pythonhosted.org/packages/6d/80/10a9ae6fa0940f25af32739d1dc6dfdbbd
       |████████████████████████████████| 49.5MB 83kB/s
  Requirement already satisfied: numpy>=1.13.3 in /usr/local/lib/python3.6/dist-packages (from o
  ERROR: albumentations 0.1.12 has requirement imgaug<0.2.7,>=0.2.5, but you'll have imgaug 0.2.
  Installing collected packages: opencv-python
  Successfully installed opencv-python-4.4.0.46
  Collecting opencv-contrib-python
    Downloading https://files.pythonhosted.org/packages/b4/ec/a66505cb25704066235369c8a1c1ed8d37
       |████████████████████████████████| 55.7MB 89kB/s
  Requirement already satisfied: numpy>=1.13.3 in /usr/local/lib/python3.6/dist-packages (from o
  Installing collected packages: opencv-contrib-python
  Successfully installed opencv-contrib-python-4.4.0.46
```

```
cv2.__version__
```

```
import numpy as np
import cv2 as cv
import matplotlib.pyplot as plt

img = cv.imread('/content/Village_Dataset/geotagged-images/IMG_7727.JPG')
gray= cv.cvtColor(img,cv.COLOR_BGR2GRAY)
sift = cv.SIFT_create()
kp = sift.detect(gray,None)
img=cv.drawKeypoints(gray,kp,img)
# cv.imwrite('sift_keypoints.jpg',img)
plt.imshow(img)
```

```
<matplotlib.image.AxesImage at 0x7f1e30b19ef0>
```

Speeded-Up Robust Features (SURF)

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
%matplotlib inline

# Load the image
image1 = cv2.imread('/content/Village_Dataset/geotagged-images/IMG_7737.JPG')

# Convert the training image to RGB
training_image = cv2.cvtColor(image1, cv2.COLOR_BGR2RGB)

# Convert the training image to gray scale
training_gray = cv2.cvtColor(training_image, cv2.COLOR_RGB2GRAY)

# Create test image by adding Scale Invariance and Rotational Invariance
test_image = cv2.pyrDown(training_image)
test_image = cv2.pyrDown(test_image)
num_rows, num_cols = test_image.shape[:2]

rotation_matrix = cv2.getRotationMatrix2D((num_cols/2, num_rows/2), 30, 1)
test_image = cv2.warpAffine(test_image, rotation_matrix, (num_cols, num_rows))

test_gray = cv2.cvtColor(test_image, cv2.COLOR_RGB2GRAY)

# Display traning image and testing image
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("Training Image")
plots[0].imshow(training_image)

plots[1].set_title("Testing Image")
plots[1].imshow(test_image)
```

```
<matplotlib.image.AxesImage at 0x7f7b465ccef0>
```


```
surf = cv2.xfeatures2d.SURF_create(800)

train_keypoints, train_descriptor = surf.detectAndCompute(training_gray, None)
test_keypoints, test_descriptor = surf.detectAndCompute(test_gray, None)

keypoints_without_size = np.copy(training_image)
keypoints_with_size = np.copy(training_image)

cv2.drawKeypoints(training_image, train_keypoints, keypoints_without_size, color = (0, 255, 0))

cv2.drawKeypoints(training_image, train_keypoints, keypoints_with_size, flags = cv2.DRAW_MATCHES_FLA

# Display image with and without keypoints size
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("Train keypoints With Size")
plots[0].imshow(keypoints_with_size, cmap='gray')

plots[1].set_title("Train keypoints Without Size")
plots[1].imshow(keypoints_without_size, cmap='gray')

# Print the number of keypoints detected in the training image
print("Number of Keypoints Detected In The Training Image: ", len(train_keypoints))

# Print the number of keypoints detected in the query image
print("Number of Keypoints Detected In The Query Image: ", len(test_keypoints))
```

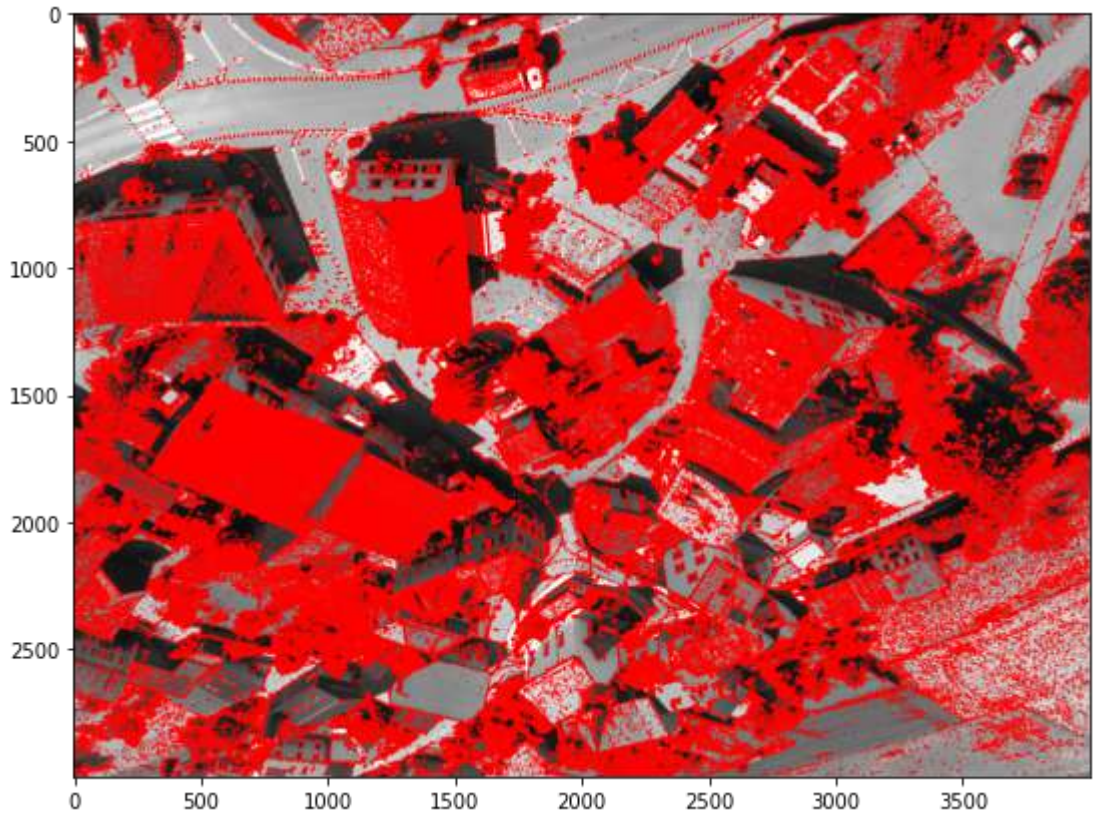
```
# Create a Brute Force Matcher object.
bf = cv2.BFMatcher(cv2.NORM_L1, crossCheck = False)

# Perform the matching between the SURF descriptors of the training image and the test image
matches = bf.match(train_descriptor, test_descriptor)

# The matches with shorter distance are the ones we want.
matches = sorted(matches, key = lambda x : x.distance)

result = cv2.drawMatches(training_image, train_keypoints, test_gray, test_keypoints, matches, test_g

# Display the best matching points
plt.rcParams['figure.figsize'] = [14.0, 7.0]
plt.title('Best Matching Points')
plt.imshow(result)
plt.show()

# Print total number of matching points between the training and query images
print("\nNumber of Matching Keypoints Between The Training and Query Images: ", len(matches))
```

Features from Accelerated Segment Test (FAST)

```
import numpy as np
```

```
import cv2 as cv
from matplotlib import pyplot as plt
img = cv.imread('/content/Village_Dataset/geotagged-images/IMG_7752.JPG',0)
# Initiate FAST object with default values
fast = cv.FastFeatureDetector_create()
# find and draw the keypoints
kp = fast.detect(img,None)
img2 = cv.drawKeypoints(img, kp, None, color=(255,0,0))
# Print all default params
print( "Threshold: {}".format(fast.getThreshold()) )
print( "nonmaxSuppression:{}".format(fast.getNonmaxSuppression()) )
print( "neighborhood: {}".format(fast.getType()) )
print( "Total Keypoints with nonmaxSuppression: {}".format(len(kp)) )
# cv.imwrite('fast_true.png',img2)
plt.imshow(img2)
# Disable nonmaxSuppression
fast.setNonmaxSuppression(0)
kp = fast.detect(img,None)
print( "Total Keypoints without nonmaxSuppression: {}".format(len(kp)) )
img3 = cv.drawKeypoints(img, kp, None, color=(255,0,0))
# cv.imwrite('fast_false.png',img3)
plt.imshow(img3)
plt.show()
```

```
Threshold: 10
nonmaxSuppression:True
neighborhood: 2
Total Keypoints with nonmaxSuppression: 243648
Total Keypoints without nonmaxSuppression: 1120817
```



Binary Robust Independent Elementary Features (BRIEF)

```
import numpy as np
import cv2 as cv
from matplotlib import pyplot as plt
```

```
img = cv.imread('/content/Village_Dataset/geotagged-images/IMG_7752.JPG',0)
# Initiate FAST detector
star = cv.xfeatures2d.StarDetector_create()
# Initiate BRIEF extractor
brief = cv.xfeatures2d.BriefDescriptorExtractor_create()
# find the keypoints with STAR
kp = star.detect(img,None)
# compute the descriptors with BRIEF
kp, des = brief.compute(img, kp)
print( brief.descriptorSize() )
print( des.shape )
```

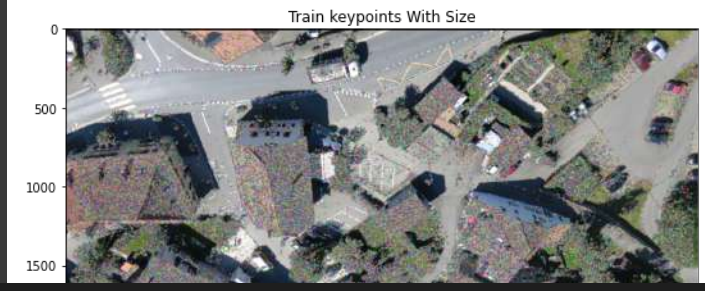
```
32
(13755, 32)
```

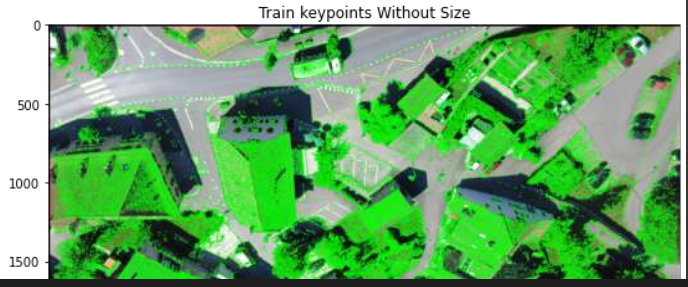
```
import cv2
import matplotlib.pyplot as plt
import numpy as np
%matplotlib inline

# Load the image
image1 = cv2.imread('/content/Village_Dataset/geotagged-images/IMG_7752.JPG')

# Convert the training image to RGB
training_image = cv2.cvtColor(image1, cv2.COLOR_BGR2RGB)

# Convert the training image to gray scale
training_gray = cv2.cvtColor(training_image, cv2.COLOR_RGB2GRAY)

# Create test image by adding Scale Invariance and Rotational Invariance
test_image = cv2.pyrDown(training_image)
test_image = cv2.pyrDown(test_image)
num_rows, num_cols = test_image.shape[:2]

rotation_matrix = cv2.getRotationMatrix2D((num_cols/2, num_rows/2), 30, 1)
test_image = cv2.warpAffine(test_image, rotation_matrix, (num_cols, num_rows))

test_gray = cv2.cvtColor(test_image, cv2.COLOR_RGB2GRAY)

# Display traning image and testing image
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("Training Image")
plots[0].imshow(training_image)

plots[1].set_title("Testing Image")
plots[1].imshow(test_image)
```

```
<matplotlib.image.AxesImage at 0x7fcbe818d828>
```

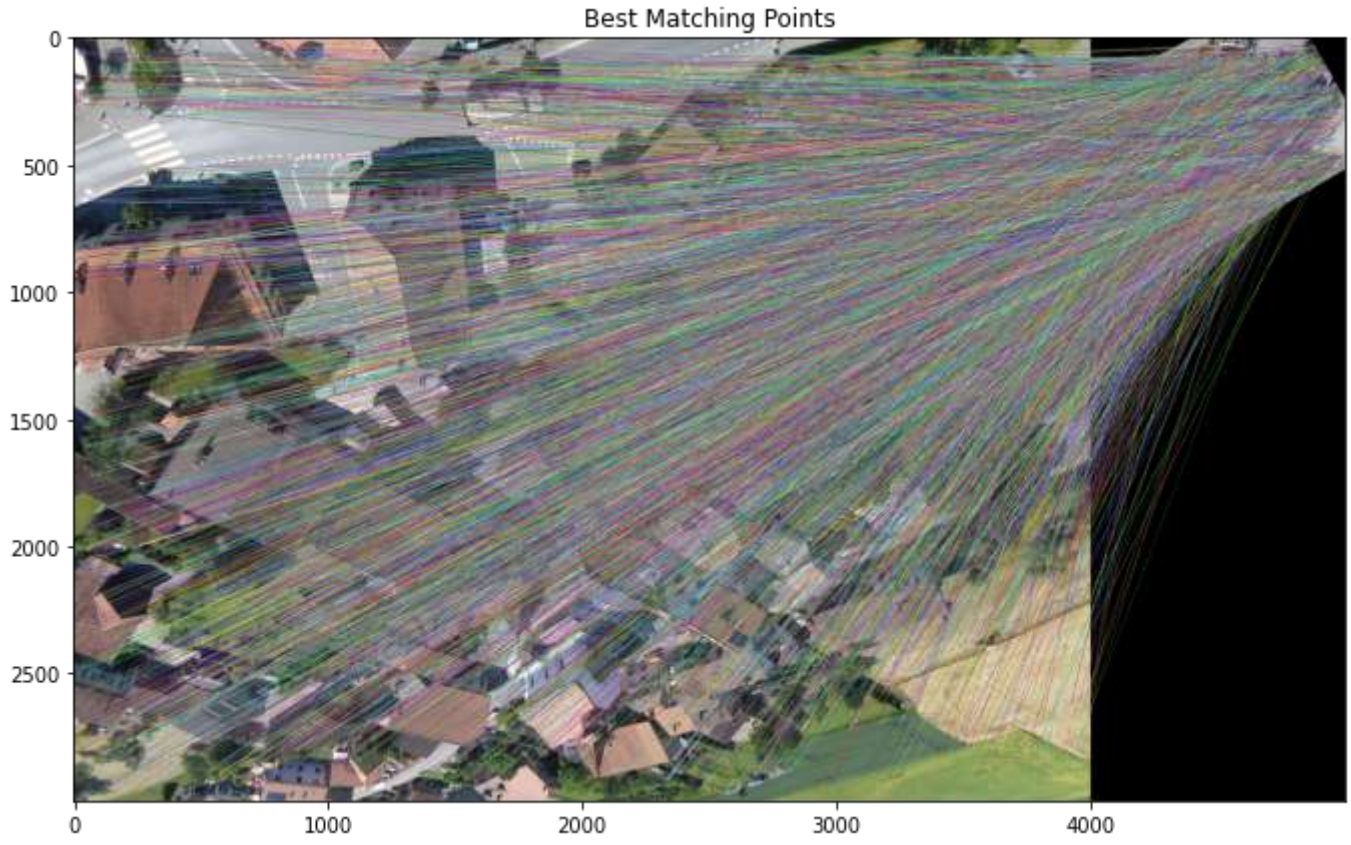

```
fast = cv2.FastFeatureDetector_create()
brief = cv2.xfeatures2d.BriefDescriptorExtractor_create()

train_keypoints = fast.detect(training_gray, None)
test_keypoints = fast.detect(test_gray, None)

train_keypoints, train_descriptor = brief.compute(training_gray, train_keypoints)
test_keypoints, test_descriptor = brief.compute(test_gray, test_keypoints)

keypoints_without_size = np.copy(training_image)
keypoints_with_size = np.copy(training_image)

cv2.drawKeypoints(training_image, train_keypoints, keypoints_without_size, color = (0, 255, 0))

cv2.drawKeypoints(training_image, train_keypoints, keypoints_with_size, flags = cv2.DRAW_MATCHES_FLA

# Display image with and without keypoints size
fx, plots = plt.subplots(1, 2, figsize=(20,10))

plots[0].set_title("Train keypoints With Size")
plots[0].imshow(keypoints_with_size, cmap='gray')

plots[1].set_title("Train keypoints Without Size")
plots[1].imshow(keypoints_without_size, cmap='gray')

# Print the number of keypoints detected in the training image
print("Number of Keypoints Detected In The Training Image: ", len(train_keypoints))

# Print the number of keypoints detected in the query image
print("Number of Keypoints Detected In The Query Image: ", len(test_keypoints))
```

```
Number of Keypoints Detected In The Training Image:  239226
Number of Keypoints Detected In The Query Image:  12480
```






```
# Create a Brute Force Matcher object.
bf = cv2.BFMatcher(cv2.NORM_HAMMING, crossCheck = True)

# Perform the matching between the BRIEF descriptors of the training image and the test image
matches = bf.match(train_descriptor, test_descriptor)

# The matches with shorter distance are the ones we want.
matches = sorted(matches, key = lambda x : x.distance)

result = cv2.drawMatches(training_image, train_keypoints, test_gray, test_keypoints, matches, test_g

# Display the best matching points
plt.rcParams['figure.figsize'] = [14.0, 7.0]
plt.title('Best Matching Points')
plt.imshow(result)
plt.show()

# Print total number of matching points between the training and query images
print("\nNumber of Matching Keypoints Between The Training and Query Images: ", len(matches))
```




```
Number of Matching Keypoints Between The Training and Query Images:  6031
```

Oriented FAST and Rotated BRIEF (ORB)

```
import numpy as np
import cv2 as cv
from matplotlib import pyplot as plt
img = cv.imread('/content/Village_Dataset/geotagged-images/IMG_7747.JPG',0)
# Initiate ORB detector
orb = cv.ORB_create()
# find the keypoints with ORB
kp = orb.detect(img,None)
# compute the descriptors with ORB
kp, des = orb.compute(img, kp)
# draw only keypoints location,not size and orientation
img2 = cv.drawKeypoints(img, kp, None, color=(0,255,0), flags=0)
plt.imshow(img2), plt.show()
```


```
(<matplotlib.image.AxesImage at 0x7fcbda787748>, None)
```

Reference:

- https://towardsdatascience.com/image-feature-extraction-traditional-and-deep-learning-techniques-ccc059195d04
- https://github.com/natowi/photogrammetry_datasets
- https://colab.research.google.com/drive/1kJihweXwBJXrbU0wKgluLXd5eYjWOSxL?usp=sharing

-By,
SUBHAYU ROY