# Harris Corner Detector implementation in Python

Code is divided in functions. Matplotlib is used to draw graphs and scikit library is used to convert image to grayscale because cv2 grayscale function did not give satisfactory results. Corner function takes the grayscale input image and calculates its corners. Horizontal and vertical shifts were earlier done by calculating shift matrix and then by warpaffine function, the matrix was applied to grayscale image. Since the resulting image was not satisfactory, sobel filters were then used to implement shifts. After calculating corners, thresholding was carried out to reduce the number of corners in the image. Alpha for calculating trace square is 0.04. Thresholding is at 120px (means all the pixel values below this value will become zero and all above this value will be set to 255).
Rotation function contains the part b of the assignment while scaling function contains the part c of the assignment. In both part b and c, same logic is used to compare the number of points between images. Inner loop translate window across width of the image and outside loop translate window across height of the image. First for loop in rotation function is to rotate image. Since 360/15=24, hence it runs for 24 times. Similarly, first loop in scaling function runs for 8 times.

```
cnr_scld = cv2.resize(cnr_orig, None, None, factor, factor, cv2.INTER_CUBIC)
```

cv2.INTER_CUBIC in resize line of scaling is for implementing bicubic interpolation. Match variable is the number of features which is set to zero before window loops start.
Key_points_n function at the end of the code is to calculate number of features (N) is the original image. It uses the same algorithm as the one used in part b and c except the fact that in this function both images compared are the same hence giving the total number of features in either image.

Program run time for image1: 72.0956998
Program run time for image2: 72.6335488

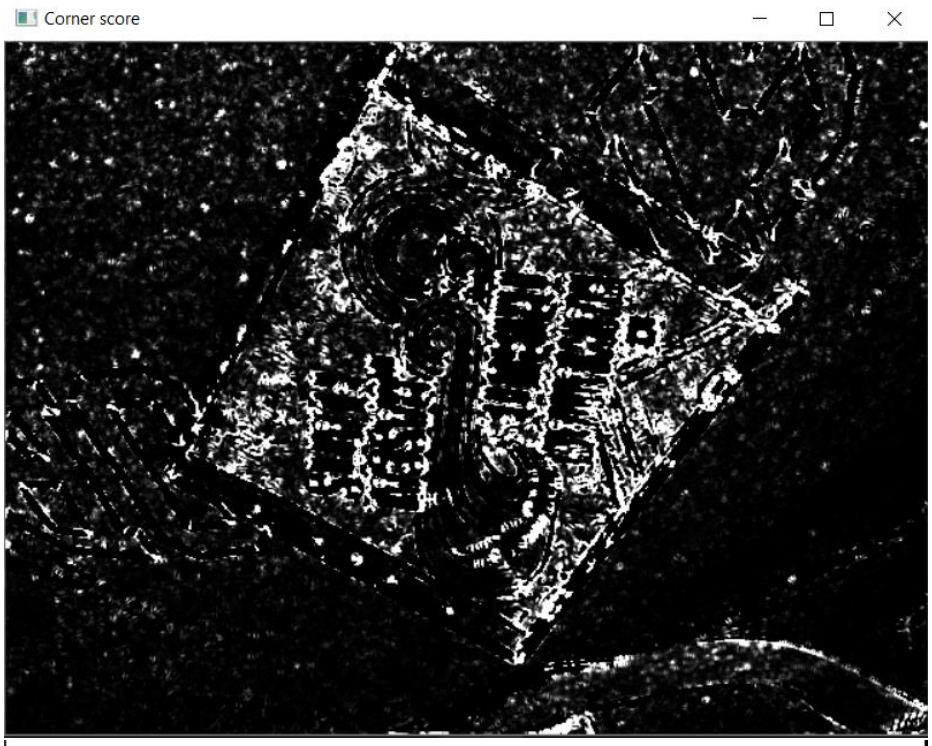
## Main function output:

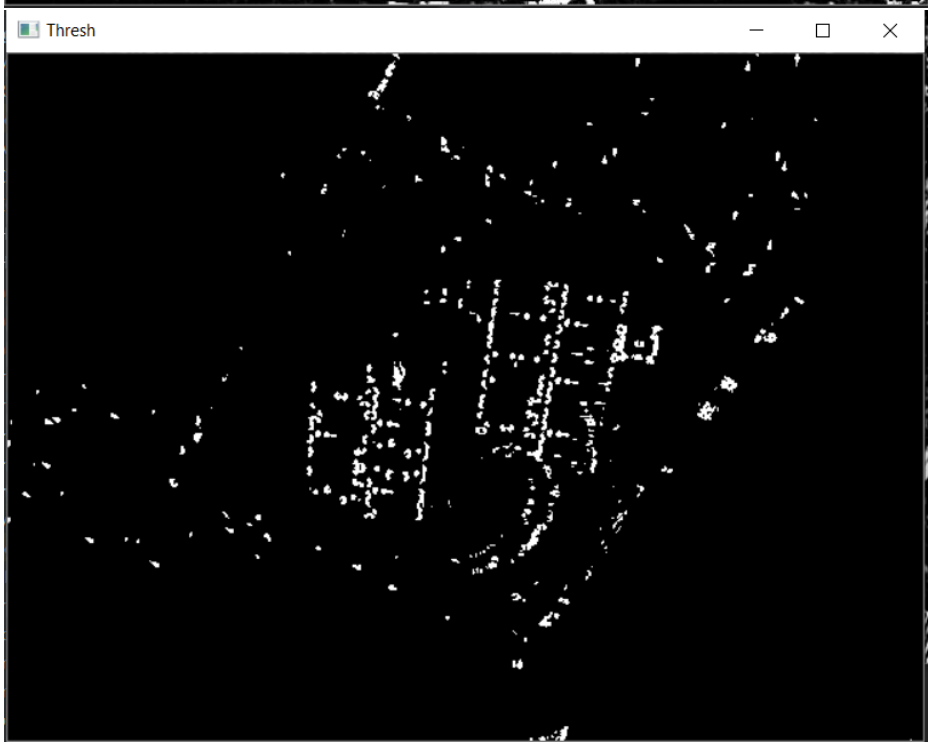
Height: 480, Widht: 640



## Corner function output:

# For image1:



Corner score


Thresh


## For image2:


SobelY


Corner score


Thresh

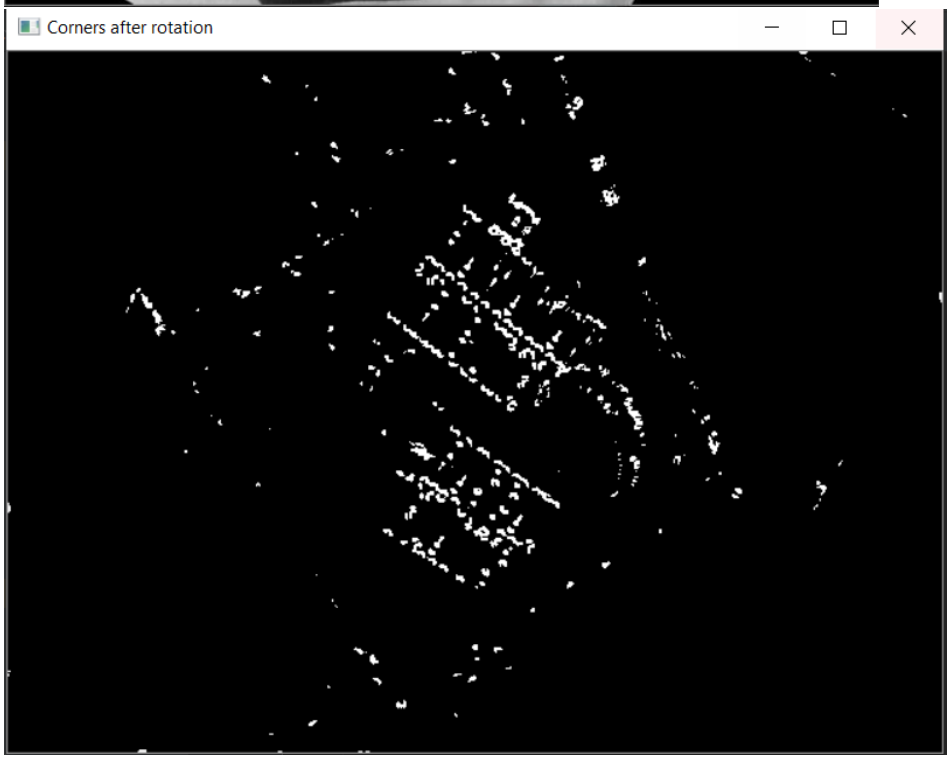

Edges

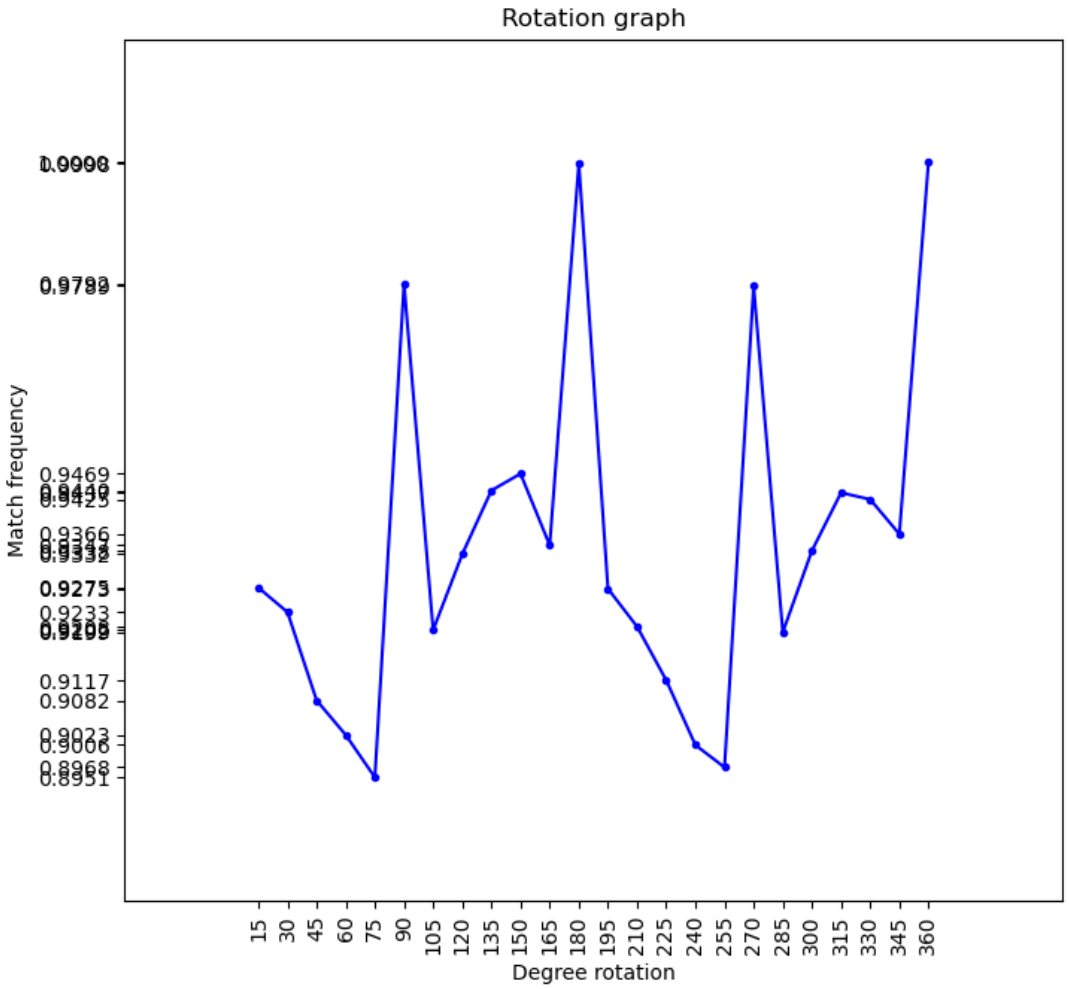
## Rotation function output:
## For image1:

At 15-degree rotation: Matches:  4872
At 30-degree rotation: Matches:  4850
At 45-degree rotation: Matches:  4771
At 60-degree rotation: Matches:  4740
At 75-degree rotation: Matches:  4702
At 90-degree rotation: Matches:  5144
At 105-degree rotation: Matches:  4834
At 120-degree rotation: Matches:  4902
At 135-degree rotation: Matches:  4959
At 150-degree rotation: Matches:  4974
At 165-degree rotation: Matches:  4910
At 180-degree rotation: Matches:  5252
At 195degree rotation: Matches:  4871
At 210-degree rotation: Matches:  4837
At 225-degree rotation: Matches:  4789
At 240-degree rotation: Matches:  4731
At 255-degree rotation: Matches:  4711
At 270-degree rotation: Matches:  5142
At 285-degree rotation: Matches:  4832
At 300-degree rotation: Matches:  4905
At 315-degree rotation: Matches:  4957
At 330-degree rotation: Matches:  4951
At 345-degree rotation: Matches:  4920
At 360-degree rotation: Matches:  5253

(M/N)-> Repeatability: [0.9274700171330669, 0.9232819341328764, 0.908242908814011, 0.9023415191319246, 0.8951075575861412, 0.9792499524081477, 0.9202360555872835, 0.9331810394060537, 0.9440319817247287, 0.9468874928612222, 0.9347039786788501, 0.9998096325909004, 0.9272796497239673, 0.9208071578145821, 0.9116695221778032, 0.9006282124500286, 0.8968208642680373, 0.9788692175899486, 0.9198553207690844, 0.9337521416333524, 0.9436512469065296, 0.9425090424519322, 0.9366076527698458, 1.0]


Rotation
THE
HAWAIIAN
TRIBUTE
TO
RASCAL
FLATTS


Corners after rotation

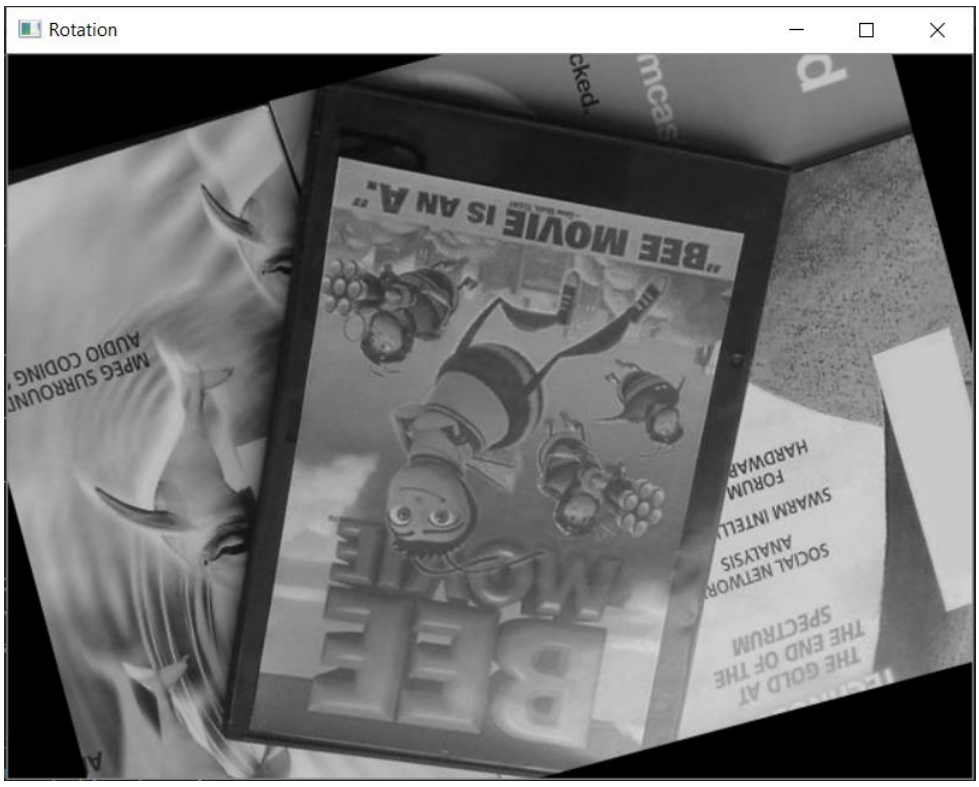



## For image2:

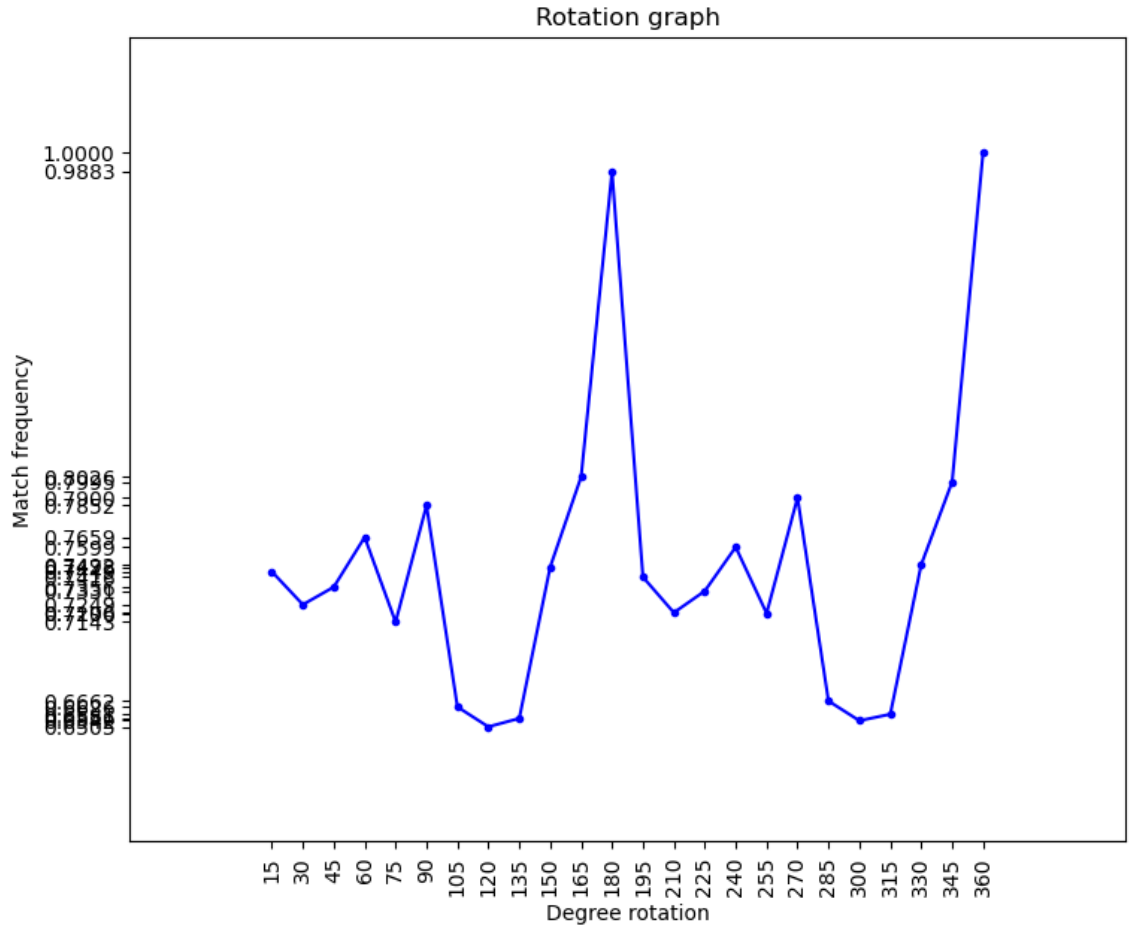
At 15-degree rotation: Matches: 7023
At 30-degree rotation: Matches: 6834
At 45-degree rotation: Matches: 6935
At 60-degree rotation: Matches: 7221
At 75-degree rotation: Matches: 6734
At 90-degree rotation: Matches: 7403
At 105-degree rotation: Matches: 6247
At 120-degree rotation: Matches: 6133
At 135-degree rotation: Matches: 6181
At 150-degree rotation: Matches: 7050
At 165-degree rotation: Matches: 7567
At 180-degree rotation: Matches: 9318
At 195-degree rotation: Matches: 6992
At 210-degree rotation: Matches: 6788
At 225-degree rotation: Matches: 6912
At 240-degree rotation: Matches: 7164
At 255-degree rotation: Matches: 6784
At 270-degree rotation: Matches: 7448

At 285-degree rotation: Matches:  6281
At 300-degree rotation: Matches:  6168
At 315-degree rotation: Matches:  6205
At 330-degree rotation: Matches:  7063
At 345-degree rotation: Matches:  7538
At 360-degree rotation: Matches:  9428

(M/N)-> Repeatability: [0.7449087823504454, 0.7248621128553245, 0.7355748833262622, 0.7659100551548579, 0.7142554094187527, 0.7852142554094188, 0.6626007636826474, 0.6505091217649555, 0.65560033941451, 0.7477725922783199, 0.8026092490453967, 0.9883326262197709, 0.7416207042851082, 0.7199830292745015, 0.7331353415358507, 0.7598642341960119, 0.7195587611370386, 0.7899872719558761, 0.6662070428510819, 0.6542214679677556, 0.6581459482392872, 0.7491514637250742, 0.7995333050487908, 1.0]




Corners after rotation

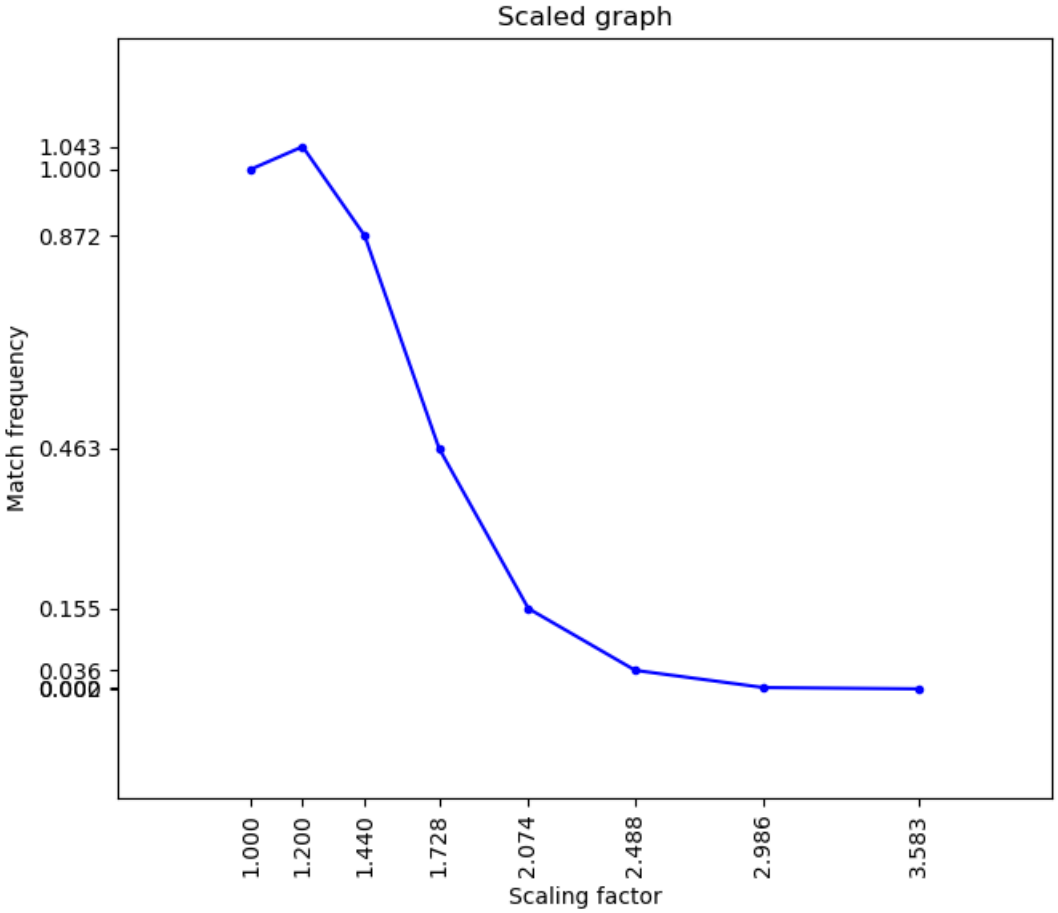

Rotation graph
Match frequency
1.0000
0.9883
0.7659
0.7143
Degree rotation
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
360

## Scaling function output:

## For image1:

Scaling factor: 1.0, Matches:  5253
Scaling factor: 1.2, Matches:  5481
Scaling factor: 1.44, Matches:  4581
Scaling factor: 1.7279999999999998, Matches:  2432
Scaling factor: 2.0736, Matches:  812
Scaling factor: 2.4883199999999994, Matches:  187
Scaling factor: 2.9859839999999993, Matches:  13
Scaling factor: 3.583180799999999, Matches:  0

(M/N)-> Repeatability: [1.0, 1.0434037692747002, 0.8720731010850943, 0.46297353893013515, 0.15457833618884448, 0.03559870550161812, 0.002474776318294308, 0.0]



## For image2:

Scaling factor: 1.0, Matches:  9428
Scaling factor: 1.2, Matches:  9552
Scaling factor: 1.44, Matches:  5847
Scaling factor: 1.7279999999999998, Matches:  4195
Scaling factor: 2.0736, Matches:  3991
Scaling factor: 2.4883199999999994, Matches:  4006
Scaling factor: 2.9859839999999993, Matches:  4233
Scaling factor: 3.583180799999999, Matches:  2078

(M/N)-> Repeatability: [1.0, 1.0131523122613493, 0.6201739499363598, 0.4449512091641918, 0.4233135341535851, 0.4249045396690709, 0.4489817564700891, 0.22040729741196435]