Computer Vision (COL 780)
Assignment-1: Automated Evaluation of Micro-sutures

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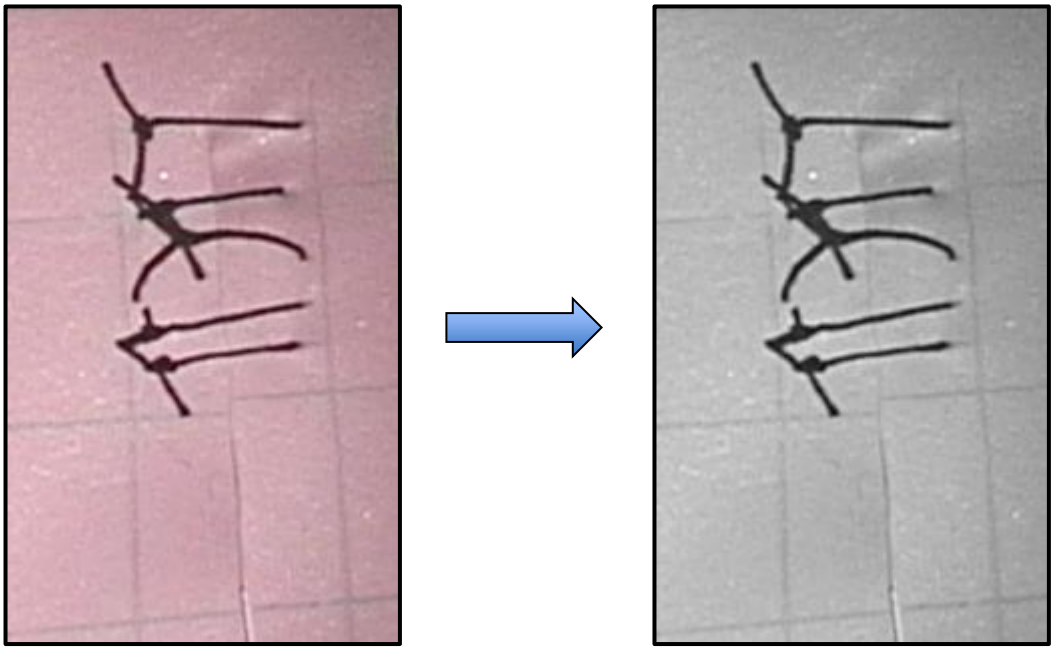
Task-1: Number of micro-sutures (Example: img2.png)

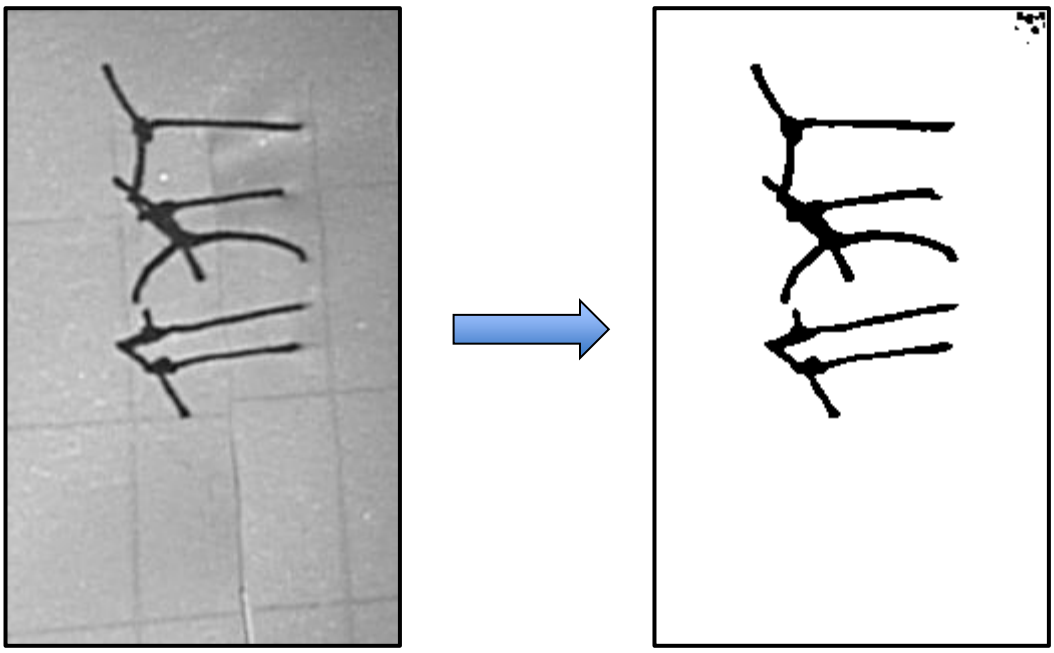
1. Conversion of each image from colored (RGB) to grayscale using cv2.cvtColor().



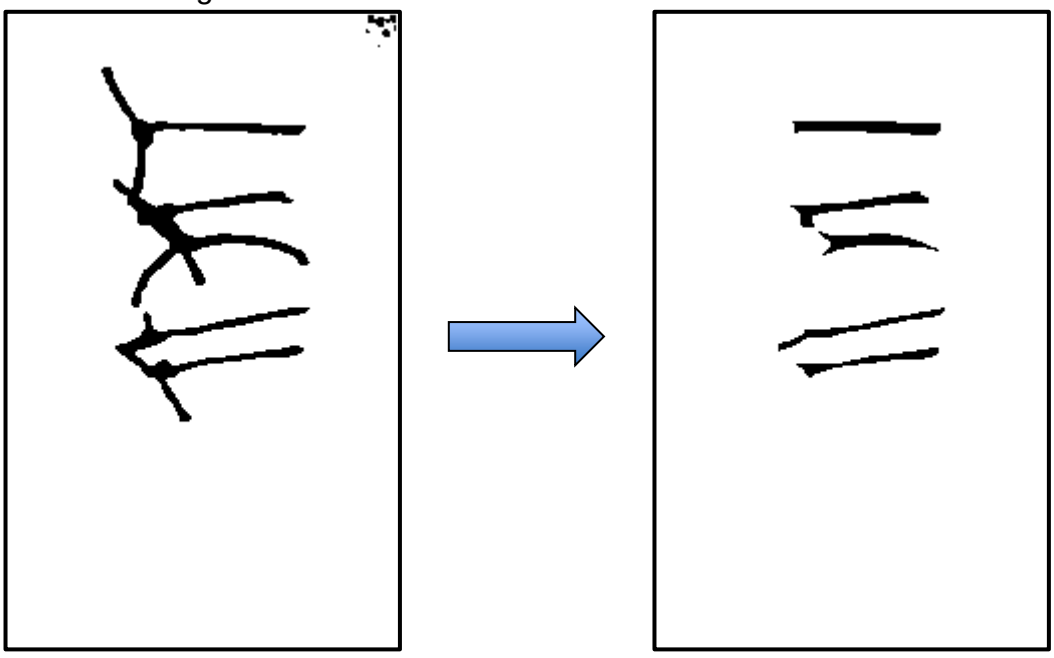
2. Blurring by convolution with a 3 x 3 Gaussian Kernel to remove noise.

   Gaussian Kernel = $\frac{1}{16}\begin{bmatrix}1 & 2 & 1\\ 2 & 4 & 2\\ 1 & 2 & 1\end{bmatrix}$

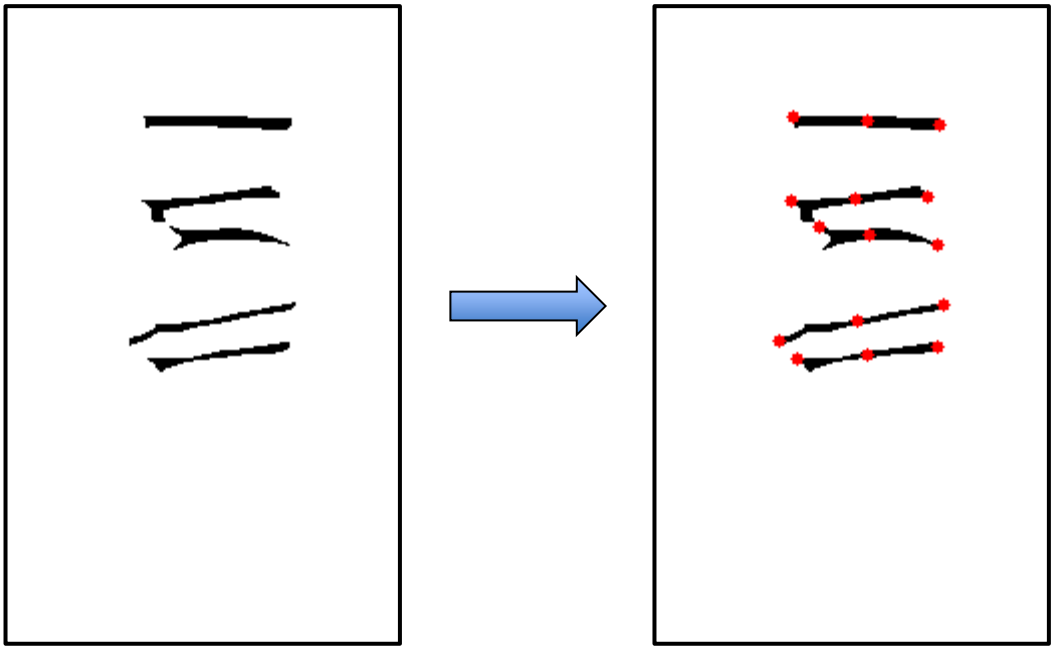
   Thresholding (at the average of the maximum pixel value and the minimum pixel value in the grayscale image) for effectively separating the background from the sutures and for converting the image into a binary image.



3. Erosion and Dilation for separating the sutures by breaking them at the connection points, if any.
   Step 1: Erosion using 3X1 Kernel
   Step 2: Dilation (3 times) using 5X1 Kernel
   Step 3: Erosion using 3X1 Kernel
   Step 4: Dilation using 3X3 Kernel



4. Use of Connected Component Algorithm (using Iterative Deepening Depth First Search) to identify the different clusters and remove the noise (small clusters of size < (average of cluster sizes)/2) from the image.

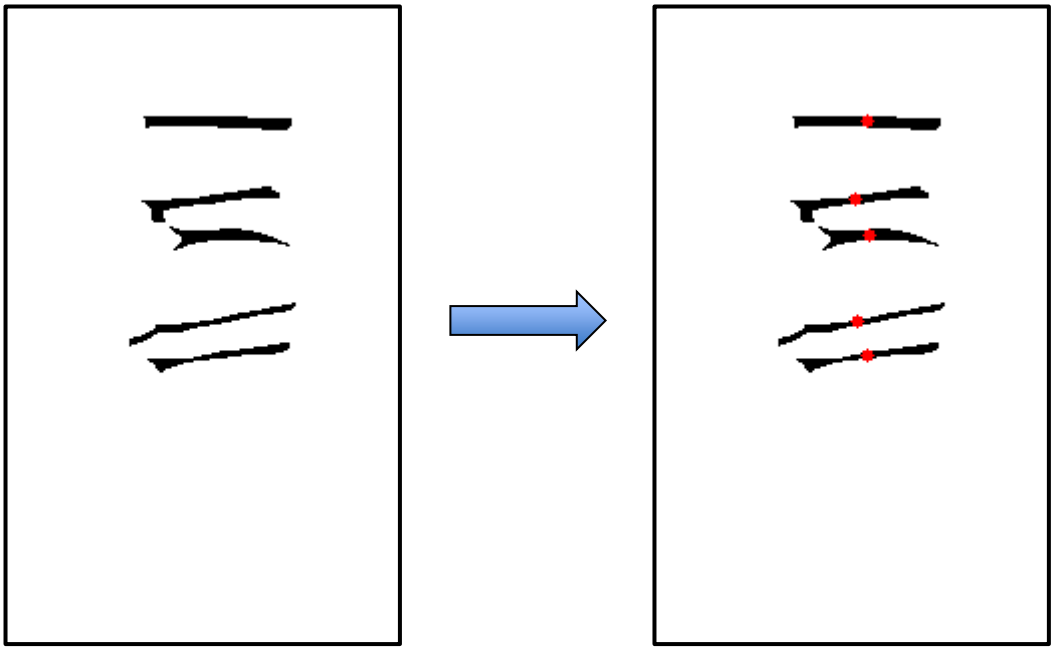


Task-2: Inter-Suture Spacing (Example: img2.png)

1. Calculation of centroid for each connected component (cluster).

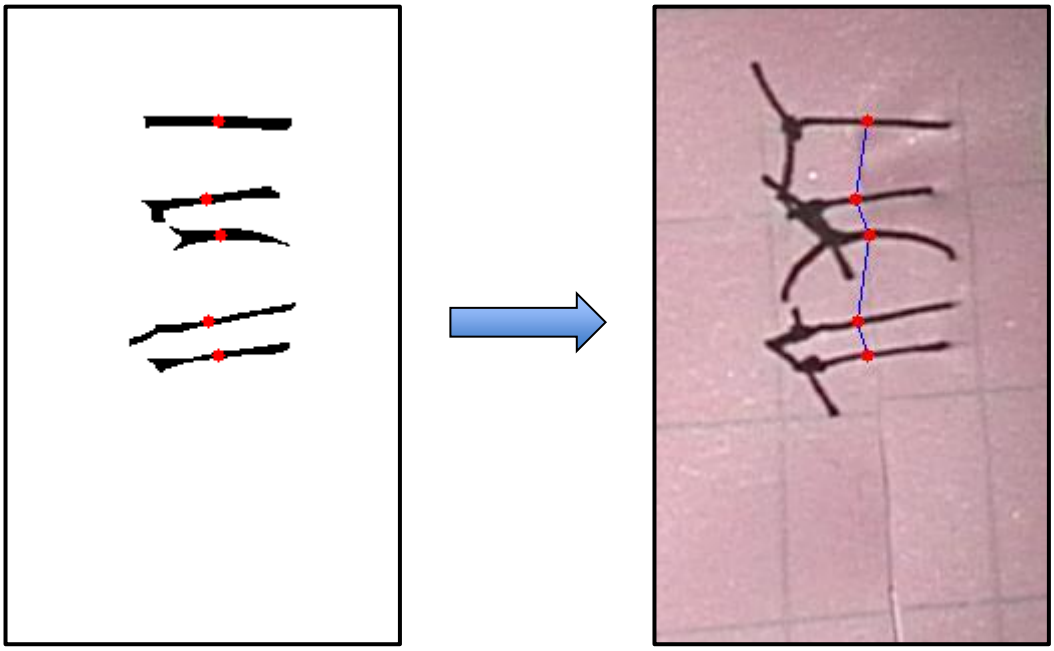
$$x_{centroid} = \frac{Summation\ of\ x\ components\ of\ the\ pixel\ coordinates\ of\ each\ cluster}{Number\ \ of\ pixels\ in\ each\ cluster}$$

$$y_{centroid} = \frac{Summation\ of\ y\ components\ of\ the\ pixel\ coordinates\ of\ each\ cluster}{Number\ \ of\ pixels\ in\ each\ cluster}$$



2. Computation of the inter-suture spacing (Euclidian distance) between consecutive centroids to measure the inter-suture spacing.

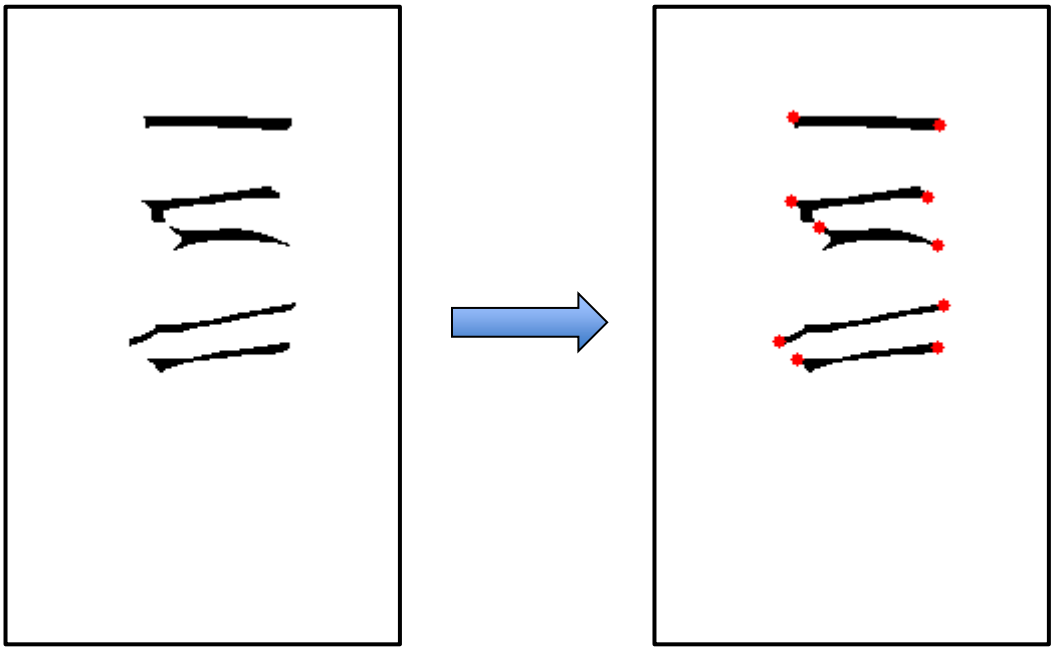
   Euclidian distance = $\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$



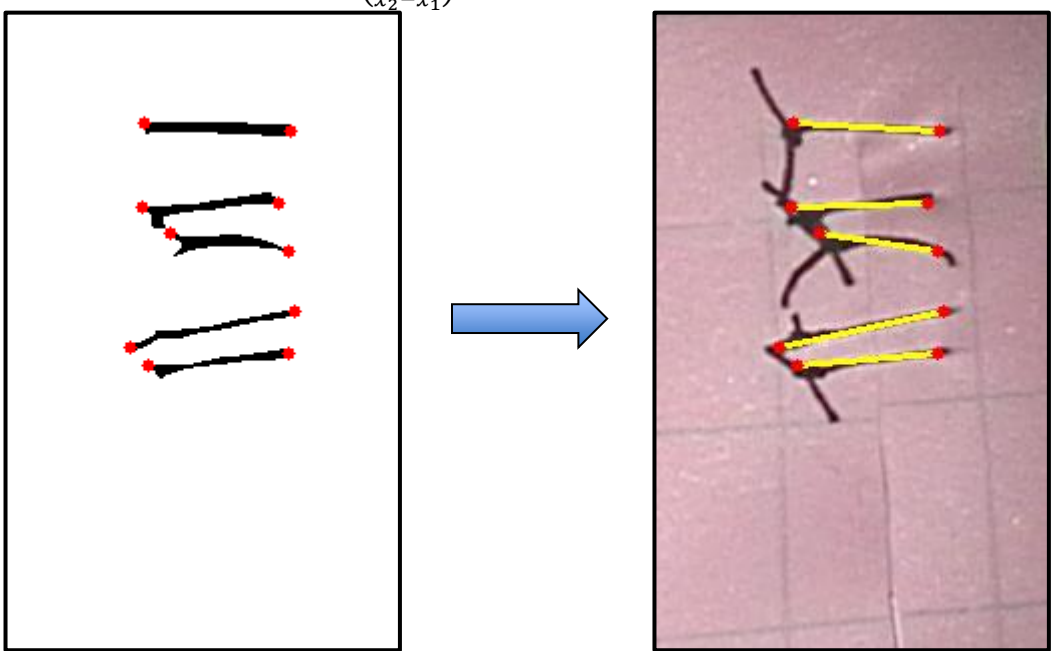
3. Division of each inter-suture spacing by the height of the image and calculation of the mean (using np.mean()) and variance (using np.var()) of inter-suture spacings of all consecutive sutures for each image.

Task-3: Angulation of the suture (Example: img2.png)

1. Calculation of leftmost and rightmost pixels for each connected component.



2. Calculation of the angle formed by the line connecting the leftmost and rightmost pixel of each connected component and the x-axis.
   Angle = $np.degrees(np.arctan\left(\frac{y_2-y_1}{x_2-x_1}\right))$



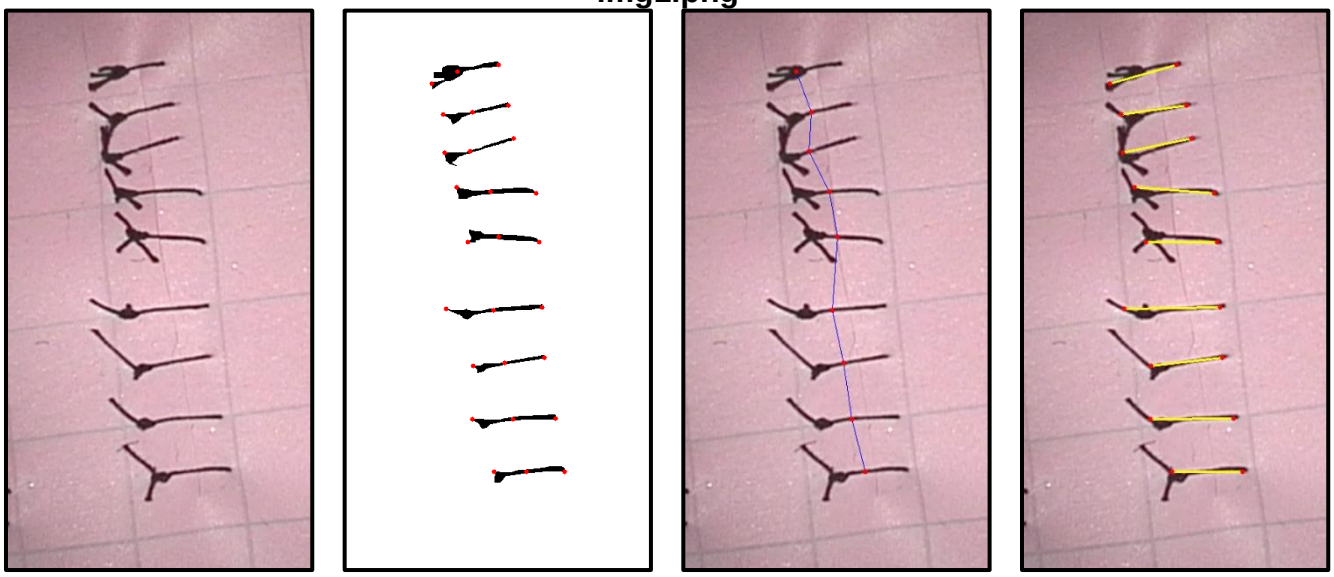
3. Calculation of the mean (using np.mean()) and variance (using np.var()) of suture angle with respect to the x-axis for each image.

Table for Part-1 (Task-1, Task-2 and Task-3) for all images in 'data' directory

image_name	number of sutures	mean inter suture spacing	variance of inter suture spacing	mean suture angle wrt x-axis	variance of suture angle wrt x-axis
img1.png	9	0.09248	0.000334	4.323581	37.676695
img10.png	20	0.088672	0.000941	-7.701298	122.953898
img2.png	5	0.094565	0.00133	1.431	50.988859
img3.png	9	0.099339	0.000413	3.436759	32.111649
img4.png	10	0.086967	0.000261	6.76063	28.47273
img5.png	10	0.0881	0.000329	-1.567323	28.65458
img6.png	13	0.064618	0.000117	0.466261	30.035845
img7.png	8	0.096089	0.001185	-3.098377	22.953966
img8.png	17	0.051854	0.000148	-1.015975	6.858166
img9.png	16	0.05695	0.000147	2.199538	11.809306

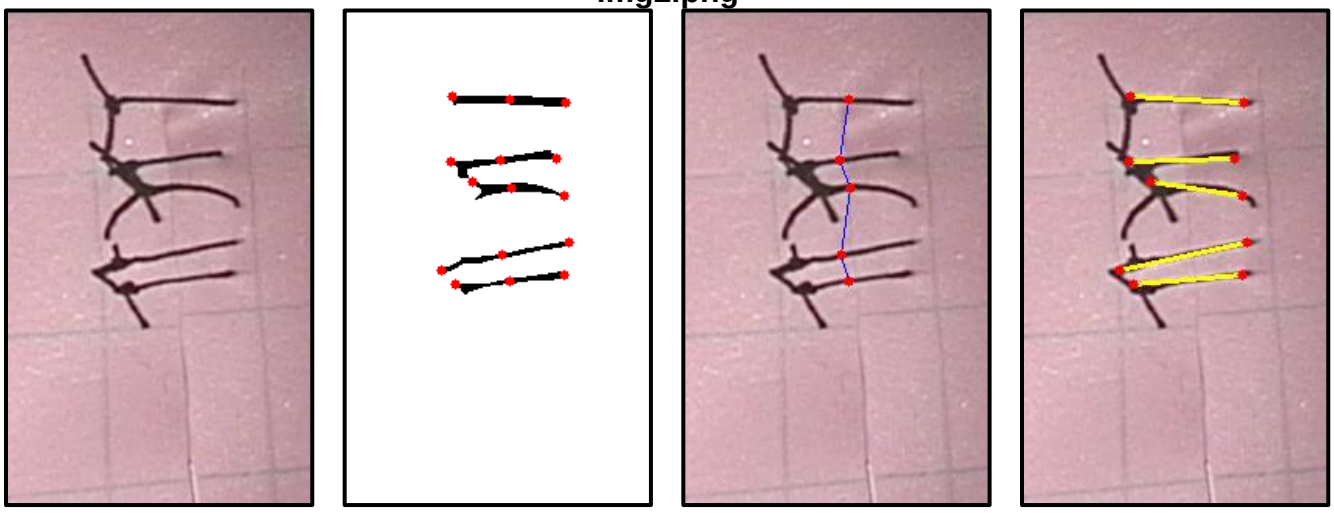
Part-1 Images with Markings (Original Image, Clusters, Centroids, Extreme Points)

img1.png



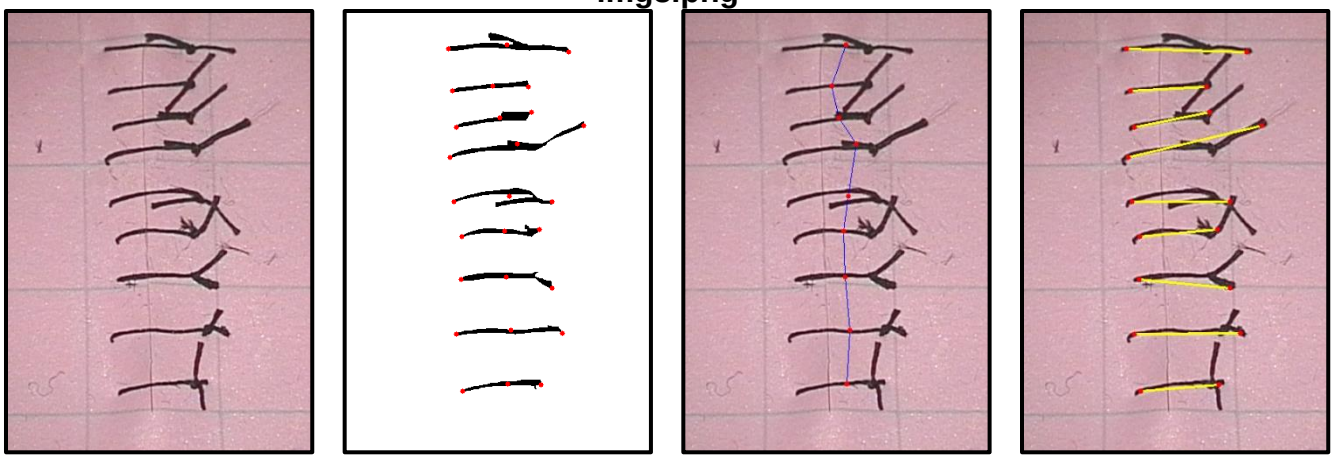
Number of sutures = 9
Mean inter suture spacing = 0.09248
Variance of inter suture spacing = 0.000334
Mean suture angle w.r.t. x-axis = 4.323581
Variance of suture angle w.r.t. x-axis = 37.676695

img2.png



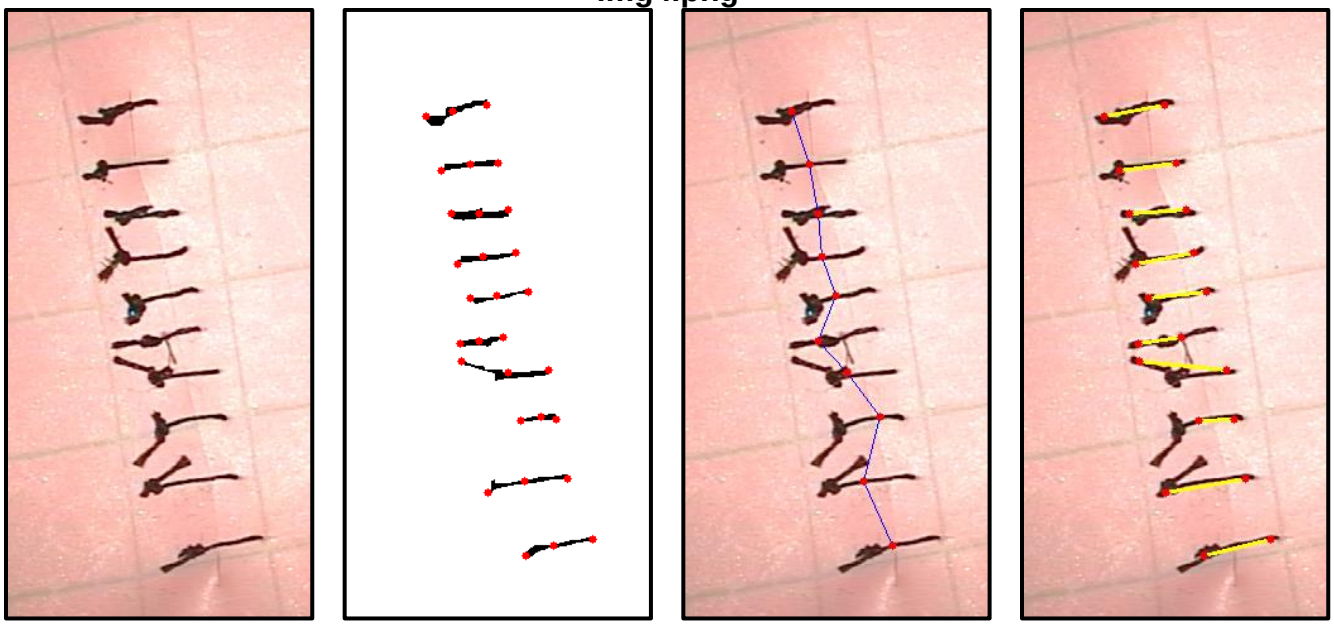
Number of sutures = 5
Mean inter suture spacing = 0.094565
Variance of inter suture spacing = 0.00133
Mean suture angle w.r.t. x-axis = 1.431
Variance of suture angle w.r.t. x-axis = 50.988859

img3.png



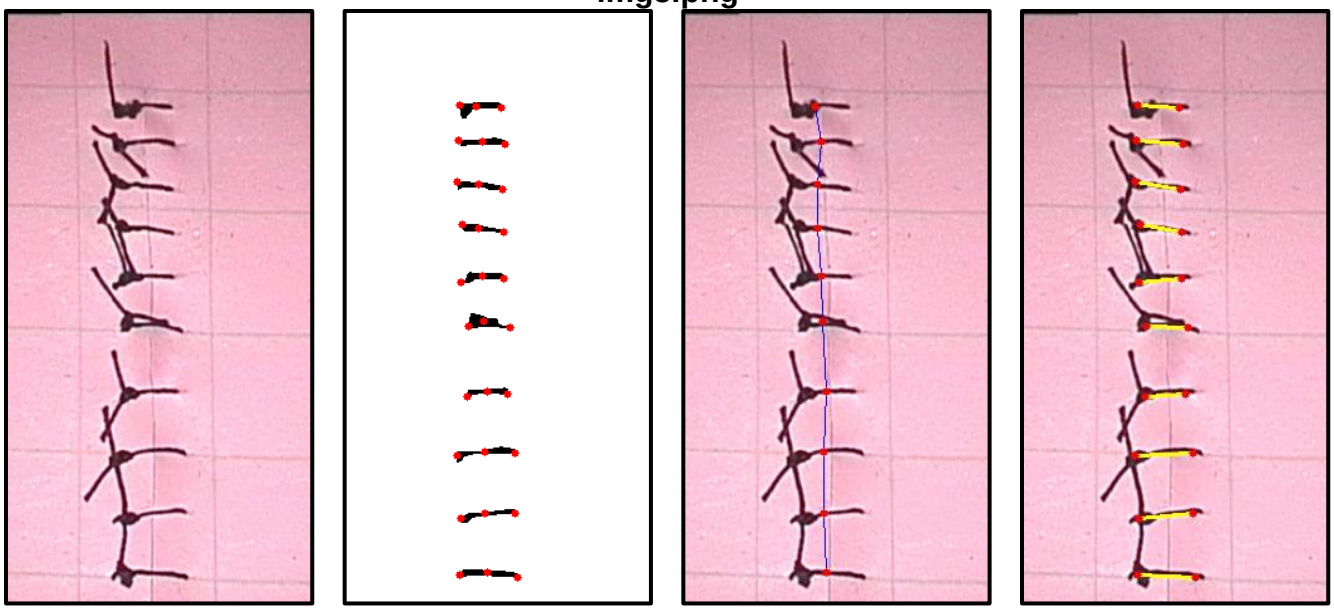
Number of sutures = 9
Mean inter suture spacing = 0.099339
Variance of inter suture spacing = 0.000413
Mean suture angle w.r.t. x-axis = 3.436759
Variance of suture angle w.r.t. x-axis = 32.111649

img4.png



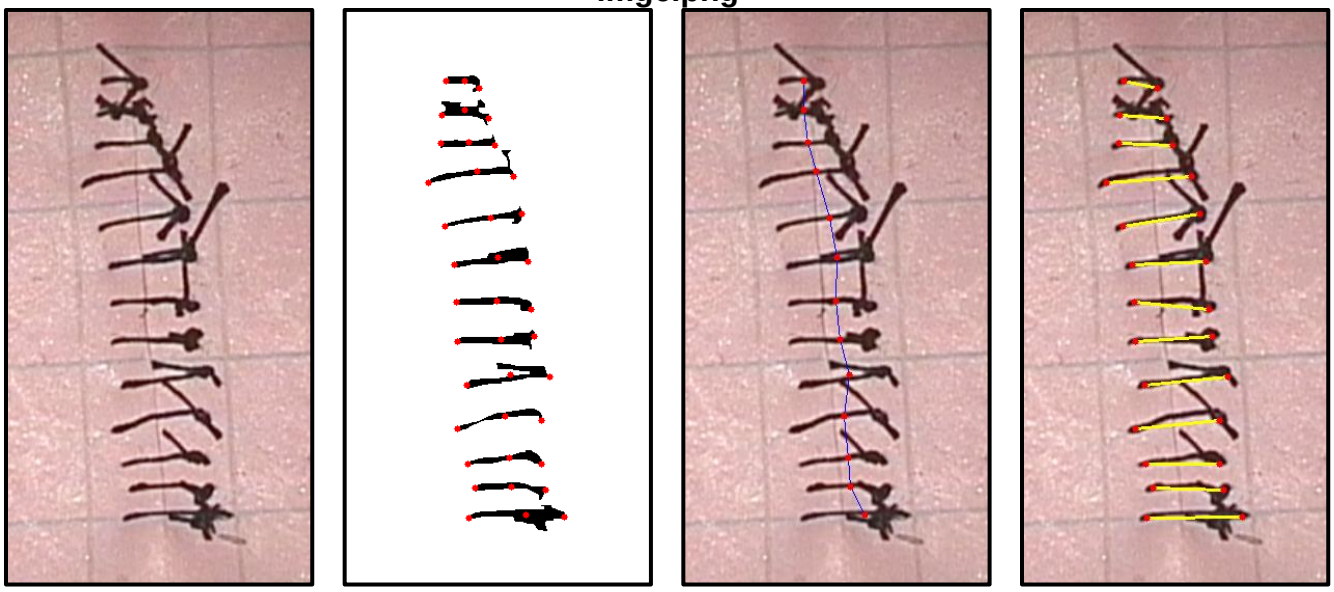
Number of sutures = 10
Mean inter suture spacing = 0.086967
Variance of inter suture spacing = 0.000261
Mean suture angle w.r.t. x-axis = 6.76063
Variance of suture angle w.r.t. x-axis = 28.47273

img5.png



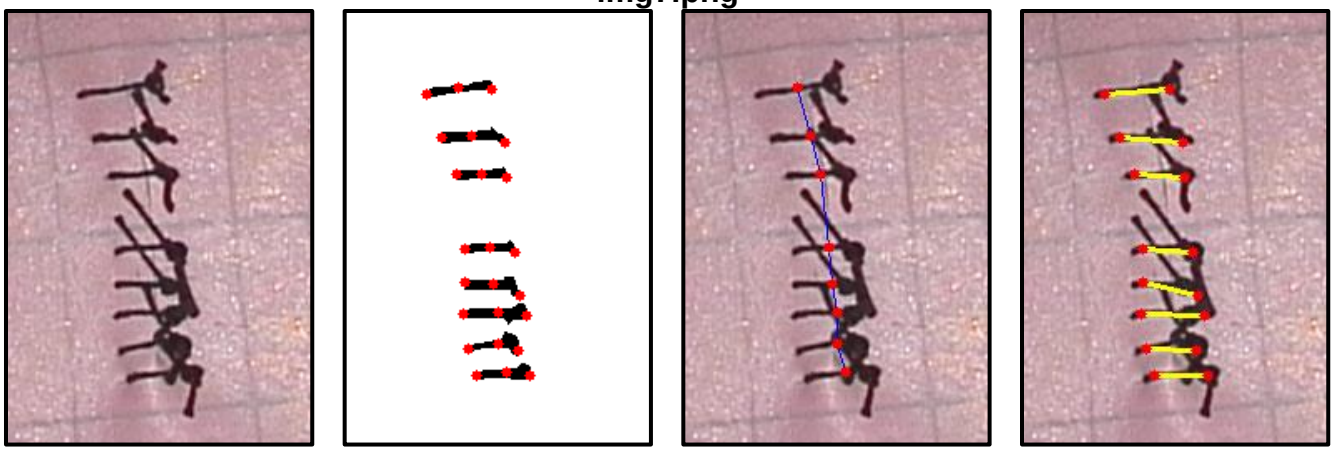
Number of sutures = 10
Mean inter suture spacing = 0.0881
Variance of inter suture spacing = 0.000329
Mean suture angle w.r.t. x-axis = -1.567323
Variance of suture angle w.r.t. x-axis = 28.65458

img6.png



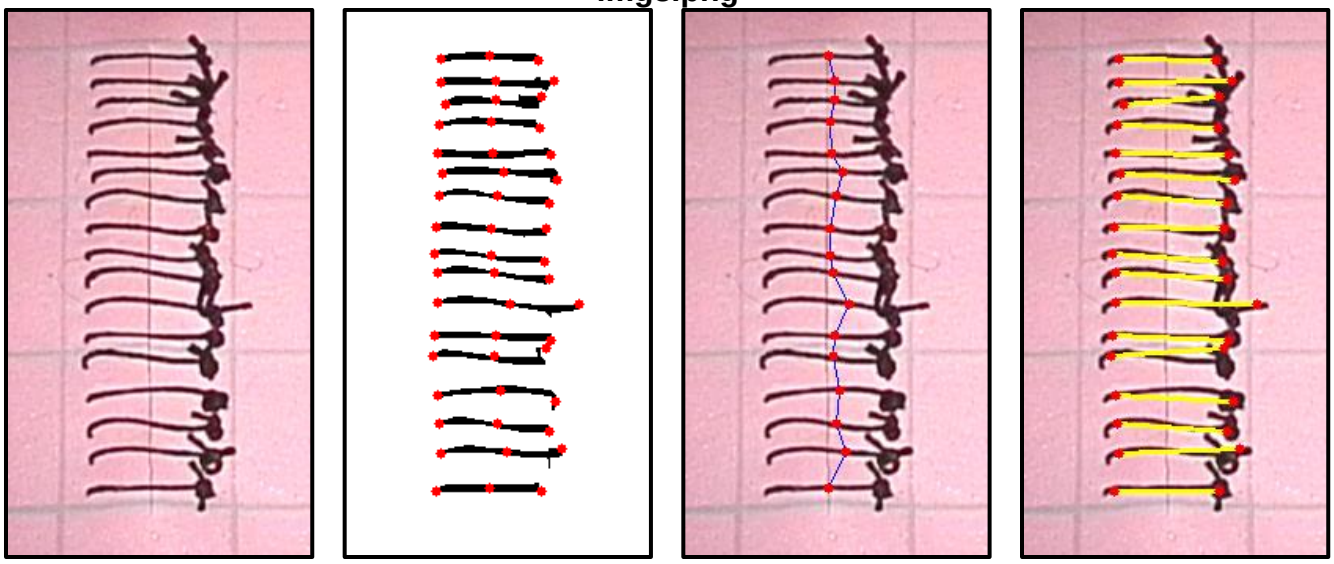
Number of sutures = 13
Mean inter suture spacing = 0.064618
Variance of inter suture spacing = 0.000117
Mean suture angle w.r.t. x-axis = 0.466261
Variance of suture angle w.r.t. x-axis = 30.035845

img7.png



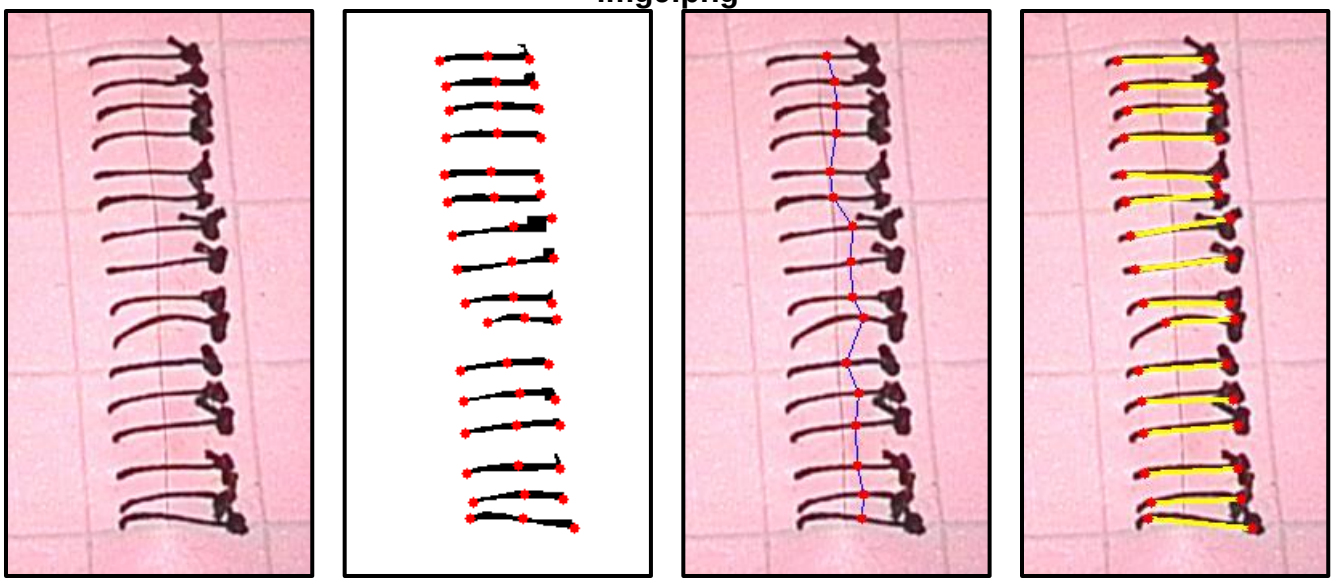
Number of sutures = 8
Mean inter suture spacing = 0.096089
Variance of inter suture spacing = 0.001185
Mean suture angle w.r.t. x-axis = -3.098377
Variance of suture angle w.r.t. x-axis = 22.953966

img8.png



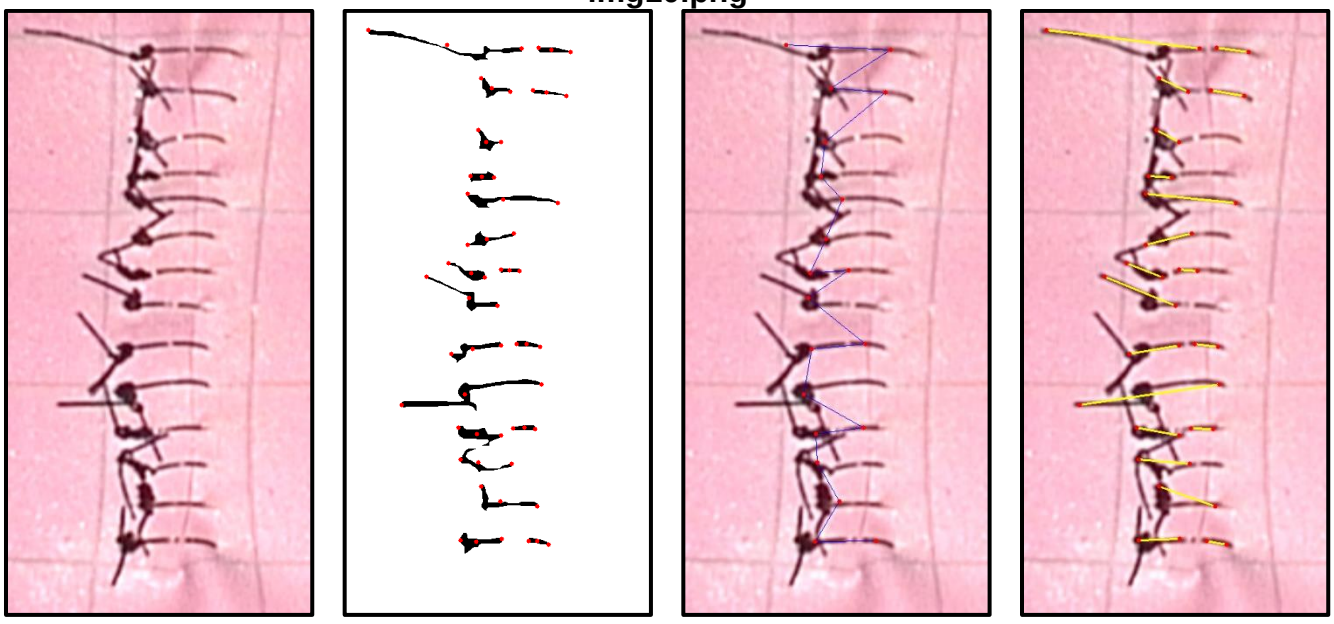
Number of sutures = 17
Mean inter suture spacing = 0.051854
Variance of inter suture spacing = 0.000148
Mean suture angle w.r.t. x-axis = -1.015975
Variance of suture angle w.r.t. x-axis = 6.858166

img9.png



Number of sutures = 16
Mean inter suture spacing = 0.05695
Variance of inter suture spacing = 0.000147
Mean suture angle w.r.t. x-axis = 2.199538
Variance of suture angle w.r.t. x-axis = 11.809306

img10.png



Number of sutures = 20
Mean inter suture spacing = 0.088672
Variance of inter suture spacing = 0.000941
Mean suture angle w.r.t. x-axis = -7.701298
Variance of suture angle w.r.t. x-axis = 122.953898

Task-4: Comparison of two micro-suturing outcomes

For two different images, a comparison of the inter-suture spacing and the angulation of sutures (with respect to variance) for finding the image that is “better” with respect to both features.

Table for Part-2 (Task-4)

img1_path	img2_path	output_distance	output_angle
data/img1.png	data/img2.png	1	1
data/img1.png	data/img4.png	2	2
data/img1.png	data/img6.png	2	2
data/img1.png	data/img8.png	2	2
data/img1.png	data/img10.png	1	1
data/img3.png	data/img4.png	2	2
data/img3.png	data/img6.png	2	2
data/img3.png	data/img8.png	2	2
data/img3.png	data/img10.png	1	1
data/img5.png	data/img6.png	2	1
data/img5.png	data/img8.png	2	2
data/img5.png	data/img10.png	1	1
data/img7.png	data/img8.png	2	2
data/img7.png	data/img10.png	2	1
data/img9.png	data/img10.png	1	1
data/img2.png	data/img4.png	2	2
data/img2.png	data/img6.png	2	2
data/img2.png	data/img8.png	2	2
data/img2.png	data/img10.png	2	1
data/img4.png	data/img6.png	2	1
data/img4.png	data/img8.png	2	2
data/img4.png	data/img10.png	1	1
data/img6.png	data/img8.png	1	2
data/img6.png	data/img10.png	1	1

Library functions used:

1. NumPy: np.zeros(), np.ones(), np.array(), np.pad(), np.fliplr(), np.flipud(), np.sum(), np.max(), np.min(), np.mean(), np.median(), np.var(), np.degrees(), np.arctan()
2. Pandas: pd.DataFrame(), pd.read_csv(), df.to_csv()
3. OpenCV: cv2.imread(), cv2.cvtColor, cv2.line(), cv2.circle(), cv2.imwrite()
4. os: os.path.exists(), os.makedirs(), os.path.splitext(), os.path.basename(), os.listdir(), os.path.join()
5. sys: sys.argv()