UNIVERSITY OF MALTA
DEPARTMENT OF COMMUNICATIONS AND COMPUTER ENGINEERING

Lab #1: Image Registration

Course: *Computer Vision (CCE5205)* – Lecturer: *Dr. Reuben Farrugia*

The aim of this laboratory session is to develop an image registration algorithm suitable to register faces on a reference coordinate system. Download the Data/ folder from the VLE. This folder contains three images: i) thor.png, ii) captainamerica.png and iii) hulk.png and a .csv file that contains the landmark points.

Question 1: Import the matplotlib package and use it to display the image of Thor.

Figure 1: Original image of Thor

Question 2 Use the pandas library to read the data from landmarks.csv. Print the output of the Dataframe.

The first column corresponds to the name of the image that will be considered in this experiment. For now we are interested in the first row that contains the landmark coordinates for the thor.png image. The remaining columns correspond to the landmark coordinates i.e. the coordinate of a specific facial feature. The coordinates (RE_x, RE_y) correspond the the (x, y) coordinates for the right eye. Similarly, LE, NC, RM, CM and LM correspond the the coordinate for the lefy-eye, nose-center, right-mouth, center-mouth and left-mouth respectively.

Question 3: Use the pandas package to extract the landmarks corresponding to each facial feature for the thor.png image. Use the scatter function to superimpose the landmarks on the displayed image.

	Name	REx	REy	LEx	LEy	NCx	NCy	RMx	RMy	CMx	CMy	LMx	LMy
0	thor	1373	314	1430	316	1382	337	1366	380	1383	376	1409	379
1	hulk	377	150	426	150	401	172	377	198	400	198	422	196
2	captainamerica	413	102	463	102	448	131	426	160	445	160	459	159

Figure 2: Dataframe read from the landmarks.csv file

Figure 3: Zoomed in image of thor.png with landmarks superimposed.

Question 4: We would like to transform (move) pixels from the thor.png image to a reference coordinage system. The reference coordinate system is as follows: $RE_x = 30$, $RE_y = 30$, $LE_x = 98$, $LF_y = 30$, $CN_x = 64$, $CN_y = 64$, $RM_x = 48$, $RM_y = 98$, $CM_x = 64$, $CM_y = 98$, $RM_x = 80$ and $RM_y = 98$. Use these reference coordinates together with the landmark coordinates for the thor.png image to formulate this image restoration problem.

Question 5: Derive the Affine transformation suitable to register the source image (thor.png) to the reference coordinate system using Least Squares. You can use functions from the numpy package.

Answer:

$$T = \begin{bmatrix} 9.61947439E^{-01} & -6.10228279E^{-02} & 0.00000000E^{+00} \\ 2.00522694E^{-01} & 1.03187293E^{+00} & 0.00000000E^{+00} \\ -1.34383770E^{+03} & -2.06980576E^{+02} & 1.00000000E^{+00} \end{bmatrix} \quad (1)$$

Question 6: Compute the matrix multiplication between the coordinates from the source image (thor.png) and the derived transformation and show that the new points are close to those of the reference coordinate system.

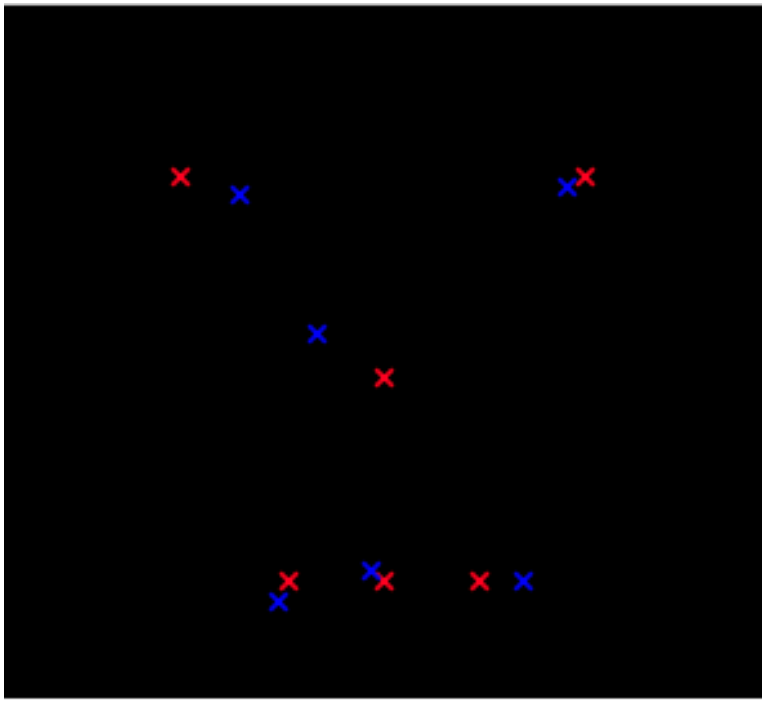

Figure 4: Comparison between the reference landmarks in red and the transformed landmarks from the source image.

Question 7: Use the following script to warp the face from the source image onto the reference coordinate system.

```
# Compute the inverse affine matrix
Tinv = np.linalg.pinv(T)

im2 = np.zeros((128,128,4))

for x in range(128):
    for y in range(128):
        # Derive the pixel coordinates to take from the reference image
        v,w,_ = np.dot([x,y,1],Tinv)
        v = np.round(v).astype('int')
        w = np.round(w).astype('int')
        im2[y,x,:] = im[w, v,:]
plt.figure()
plt.imshow(im2)
plt.axis('off')
plt.scatter(coord_ref[:,0], coord_ref[:,1],marker="x",color='blue')
plt.savefig('Result/'+avenger + '.png')
```

Question 8: Use the same script to experiment with the other two images captainamerica.png and hulk.png.

Figure 5: Thor image registered on the reference coordinate system.