HOMEWORK 2

In this exercise, you will work with geometrical transformations in 2D (and 3D if you are brave) and with the concept of interpolation.

PART 1 (score = 10 points)

Read the code available in *Example_2D_slice.m*. It loads a 3D image in variable **mrVolume**, one slice is selected and then rotated 45º with three different interpolation methods. The results are displayed on the screen. Check that you understand the code and all the functions used: *makeTransf_2D_center.m*, *Transform_2D_matrix.m*, *transform_image_2D.m.*

- *You may notice that rows and columns are switched in some places because the first dimension in a matrix corresponds to the rows, while when representing in the screen the X dimension are the columns.*

Exercise 1

Now that you understand the code, we are going to compare the original image with transformed versions for several transformation values. Save the code in *Example_2D_slice.m* with a new name (*YourName_YourNIA_HW2_Ex1.m*) and, after the last command, write the necessary commands to:

a. Rotate the original image every 3º from -150º to +150º with the linear interpolation method (you will need a loop).

b. In every rotation, calculate the sum of squared differences (SSD) between the pixel values in the original image and the ones in the rotated version.

c. Store this scalar value in every step, and after ending the loop plot the array (that will have 121 positions with the value of the correlation for every rotation angle) in a figure. Paste this figure in a document and write your explanation for the shape of the graph.

d. Repeat steps **a**, **b** and **c** but apply a range of translation or scaling values of your choice and explain the results.

Exercise 2

This second exercise is like the previous one, but now you will calculate the difference between the original image, and one that is first rotated (including interpolation) and then rotated back (with interpolation again). That is, the second image should be equivalent to the original one. Write the code (in a file named *YourName_YourNIA_HW2_Ex2.m*) to:

e. Write a loop that applies a transformation with the following parameters:
   - rotation alpha degrees
   - translation in x = 2.1
   - translation in y = 0
   - scaling in x = 1.1
   - scaling in y = 1.0

f. In every iteration of the loop, modify the alpha value every degree from -45º to +45º, and calculate the rotated image with the three available interpolation methods. In every step of the loop, calculate also a second image rotating back the image transformed with the inverse transformation.

   For instance, for iteration 1 with alfa=-45º, you will apply a transformation M to the original image with alpha=-45º and all the other parameters (scaling, translation) as explained previously (with the three interpolation methods) and then you transform back the three resulting images with the inverse transformation of M (each of them with the same interpolation method used in the first rotation).

g. In every iteration of the loop, calculate the sum of squared differences (SSD) between the pixel values in the original image and the ones in the image transformed first with M and then with the inverse of M (with the three interpolation methods).

h. Store these three values in every step, and once the loop has finished, plot the three arrays (one for every interpolation method) in a figure. Paste this figure in a document and write some explanation for the shape of the graphs, the different values depending on the interpolation method, the value that the plots have in the center or the sides of the plot, the symmetry of the graph…

Your results for this homework must be submitted to AulaGlobal within a ZIP file named *YourName_YourNIA_HW2_Ex123.zip* with the following contents:

- A PDF Document with your graphs and explanations with the name: *YourName_YourNIA_HW2_Ex123.pdf*
- Three Matlab code files named: *YourName_YourNIA_HW2_Ex1.m, YourName_YourNIA_HW2_Ex2.m* and *YourName_YourNIA_HW2_Ex3.m*

PART 2 (score = 2 extra points)

Modify the functions *makeTransf_2D_center.m*, *Transform_2D_matrix.m*, *transform_image_2D.m* to work in 3D. Use the names *makeTransf_3D_center.m*, *Transform_3D_matrix.m*, *transform_image_3D.m*

Test them by loading **mrVolume** 3D image, transform it with the following parameters:

Tx=6, Ty=-8, Tz=-4, Rx=1°, Ry=5°, Rz=65°, Sx=1.3, Sy=0.7, Sz=1.2

and show axial, coronal, and sagittal middle slices in a figure. Write all the necessary commands in a file called *YourName_YourNIA_Example_3D_volume.m.* Paste the result in a document and describe the problems you have found.

The result of this second part of your HomeWork should be submitted in a ZIP file named *YourName_YourNIA_HW2_Ex3.zip* with the Matlab ".m" files and the explanation document in PDF.