Fingerprint Biometrics Lab - Report

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Based on the provided code, complete the following document.

1.a) Copy here the two fingerprint images provided as examples (example1_1 and example1_2):

1.b) How many macro-singularities do you observe in each fingerprint?

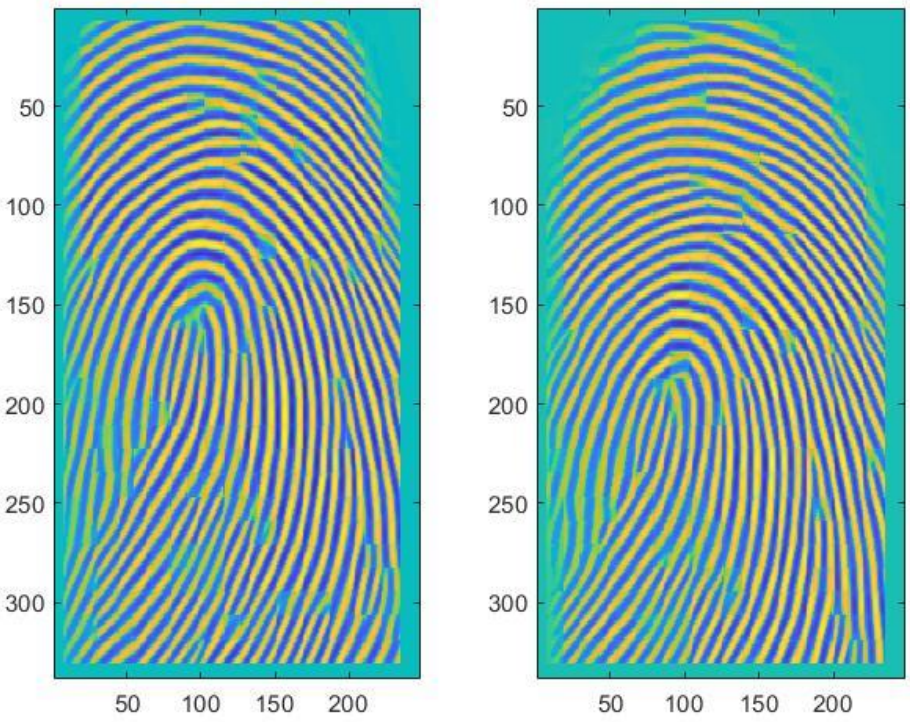
We can observe 1 loop on each image. For sure, an expert on fingerprint analysis could detect some more.

1.c) Mark the macro-singularities in the images (deltas and loops).


loop
loop

2.a) Execute the provided code for **Fingerprint Enhancement** and paste the resulting image here:

Fingerprint Enhancement - FFT Magnitude Result:

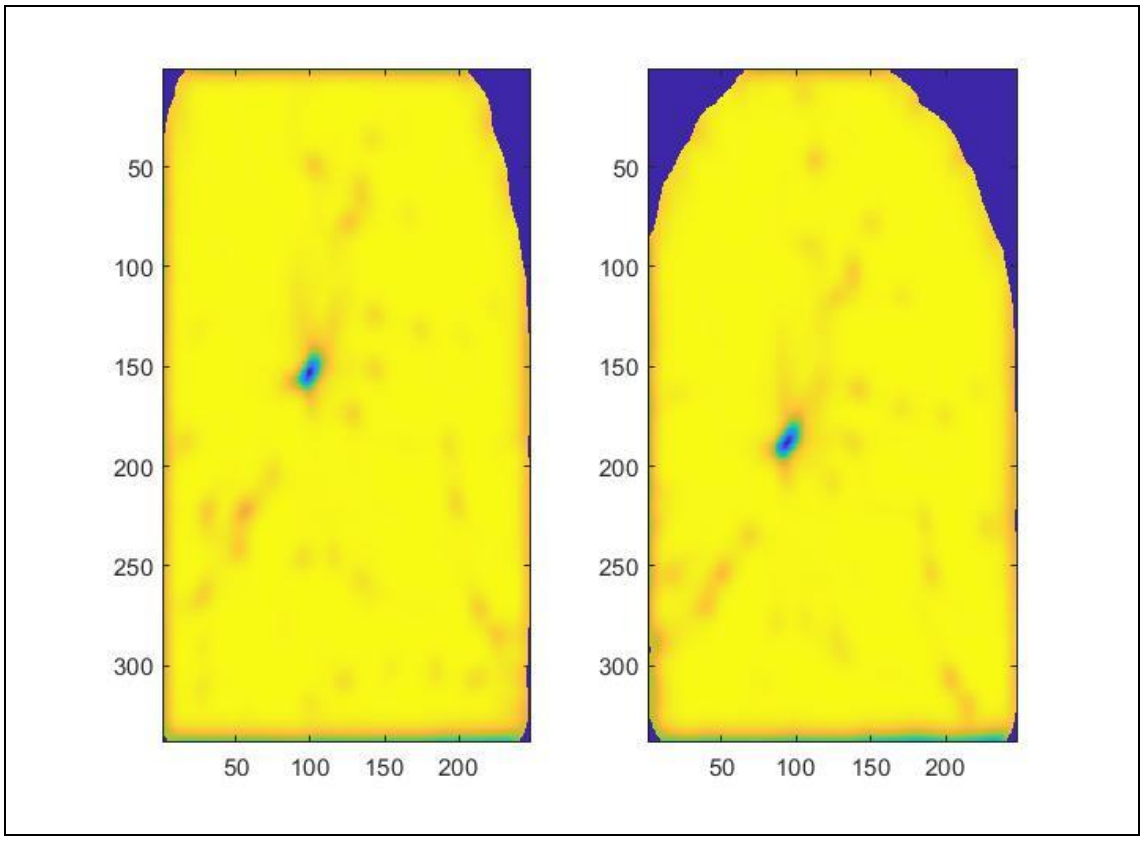


2.b) What differences do you observe with respect to the original fingerprints?

We can observe a huge difference between both fingerprints. With this technique, we emphasize the fingerprints images to see more clearly the most important features of the fingerprints, the macro-singularities (deltas and loops).

While obtaining the images we observe a yellow background and a full spectrum of colors from blue to light blue to green on the ridges. This color scale tells us where the quality of the fingerprint obtained is better. Blue means excellent ridge quality and yellow means no ridge detected. Meanwhile, the other colors of the spectrum help us detect minutaes or macro-singularities. Moreover, the image tends to show this light blue/green color at the minutaes, as some of them combine 2 ridges or a ridge end up in the middle of the fingerprint. These specific characteristics make the color of minutaes differ from the usuals or black/white.
We can observe also a light blue outside the edges background. This makes sense, as the ridges end and mix with the original or previous step with the yellow background. Although this is not an advantage to recognize the fingerprint minutaes.

3.a) Execute now the code for **Quality Maps**, and past the resulting quality maps:



3.b) What is the range of values for these quality maps?

Minimum values are represented with the color blue (value = 0), The maximum values are representing the yellow color (value = 1). The other values between 0 and 1 represent the whole range of colors

The values observed are approximately: (Coordinates Format: X = Horizontal Value, Y = Vertical Value)

Fingerprint nº1: Minimum value (X = 100, Y = 150)

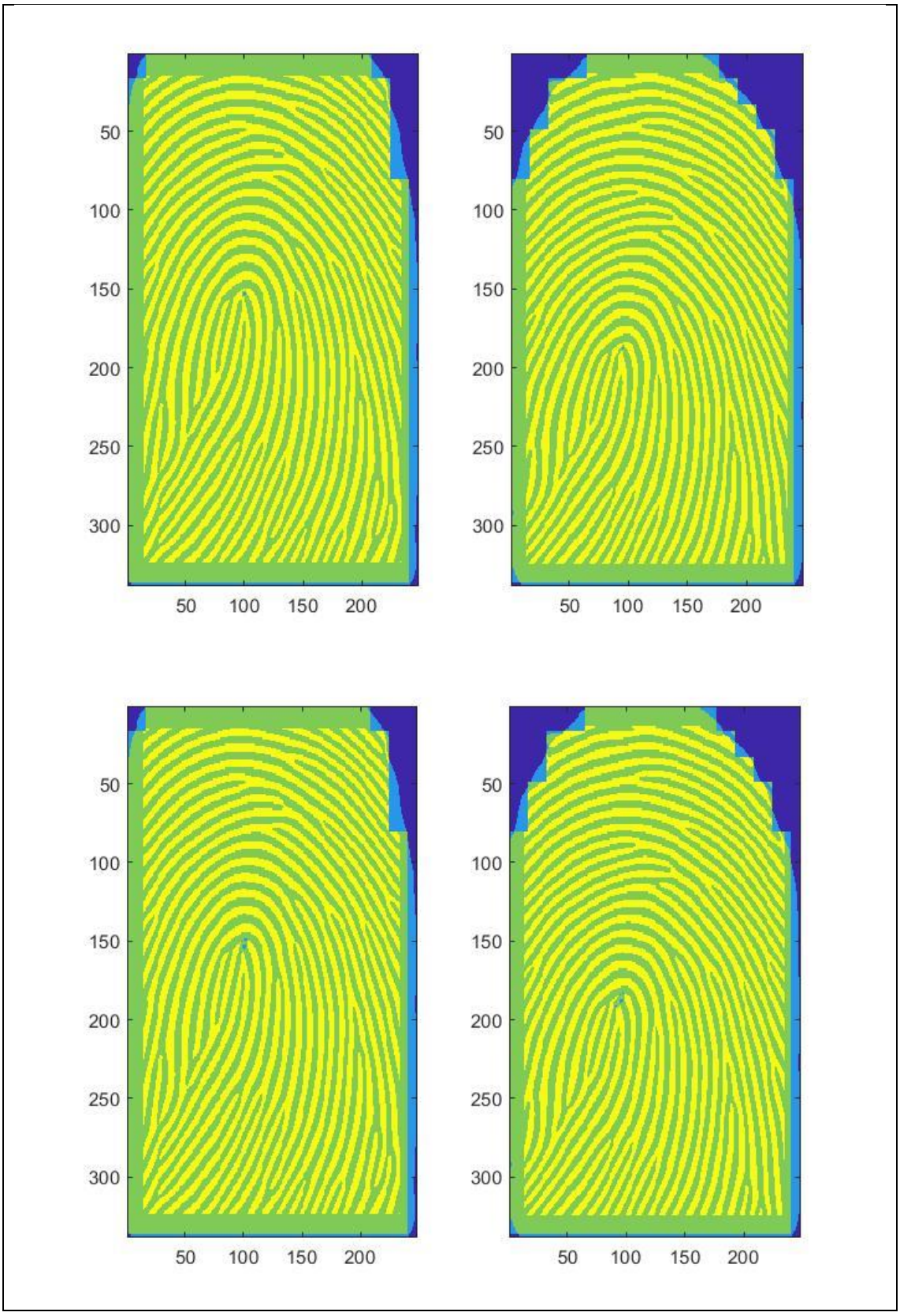
Fingerprint nº2: Minimum value (X = 90, Y = 180)

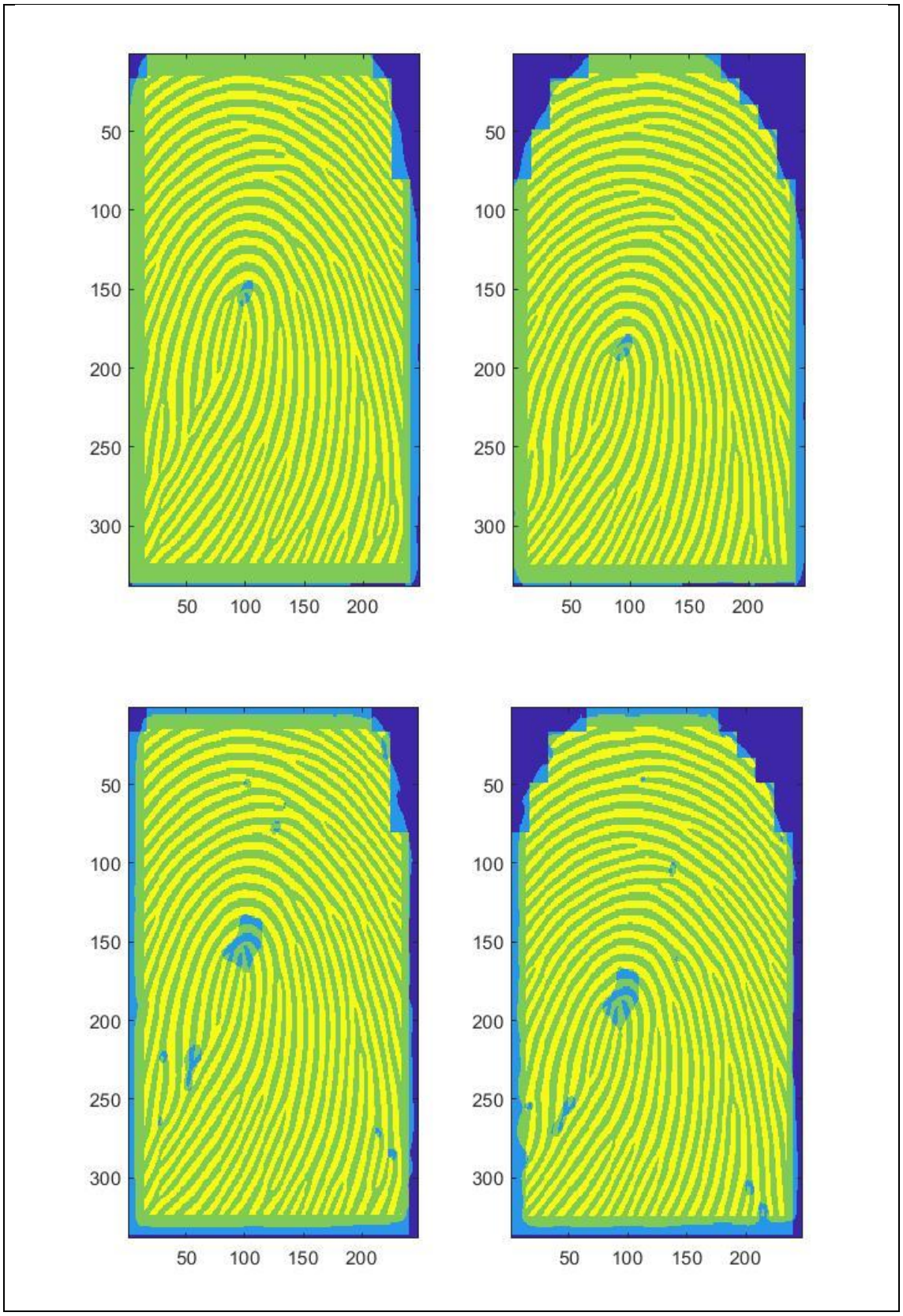
To observe this information it is necessary to print the different matrixes that are returned at the function from Quality Maps: testfin. They are not represented by a scale.

3.c) What kind information (apart from the quality) can be inferred from such code?

The quality map shows us exactly where the loop of the fingerprints by contrasting the yellow and blue colors. Being the blue color the position of this macro-singularity. Moreover, this map shows us the quality of the fingerprint image with a color spectrum from yellow (high quality), to orange/red (bad quality)

4. Execute the code in order to show the **Binarized Fingerprint and the Segmented Fingerprint**. Apply different values of quality *threshold* (0.1, 0.3, 0.6, 0.9) and paste here the resulting images:





In these pictures, it is observed the diferent loops and deltas remaked on blue color over the ridges. The higher is the threshold, the more points are highlighted. We can even see in the last image how a big part of the edge of a ridge is taken in count as a macro-singularitie.

5.a) Execute the code for generating the **Fingerprint Skeleton** and the **Minutiae Extractor**. Paste the resulting images for the original values *window=5* and *margin=5*.

We can see how this code extract the most important features and characteristics for the fingerprints given. Comparing them at the end, obtaining a similarity score shown below the images.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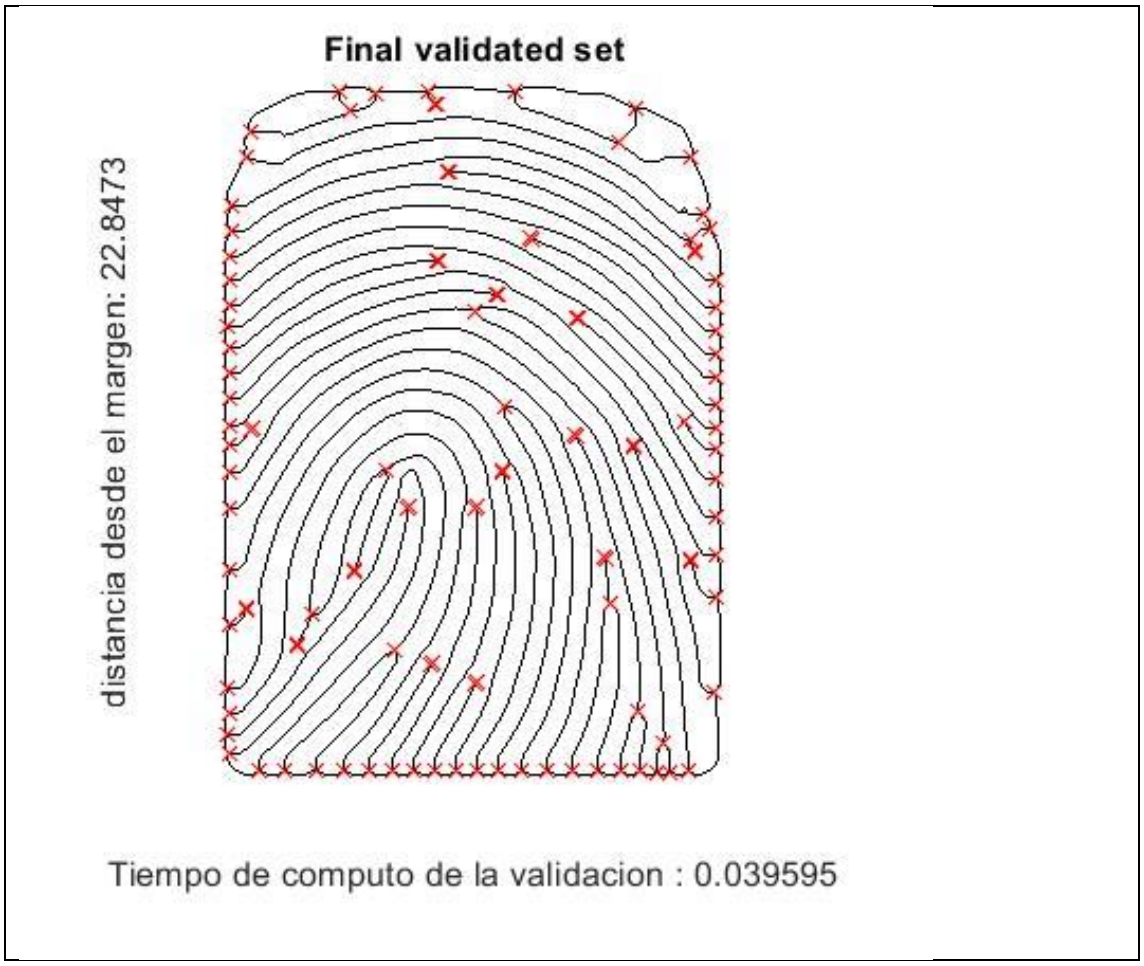
ventana: 5 margen: 5
Tiempo de computo de la extracion : 0.035268



With this variable's values, the Matching Score = 0.70588

5.b) Search heuristically by looking at the images for the optimal values of parameters *window* and *margin*. Paste the resulting images with your optimal parameters and justify your decision.

The first decision taken was reducing both variables value to 3. The window variable with value 3 work better, it increases the minutaes extracted were the value 5 couldn't reach. Because of this, the Matching Score also increases. Concluding that making a smaller window allow a better recognition of minutaes.

On the contrary, the value of 3 for the variable margin, makes the borders of the fingerprint more important extracting a greater range of minutaes at those areas. This leaves the Matching Score equal, so the decision taken was to increase it. After some tries, we know optimal value for this parameter is 20 making most of the border minutes extracted disappear, cleaning the image and getting makes a better understanding of it.

For these new values, Matching Score = 0.85714

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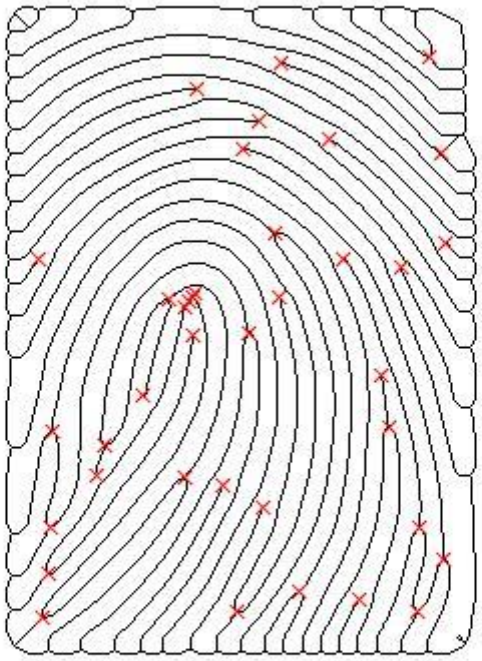
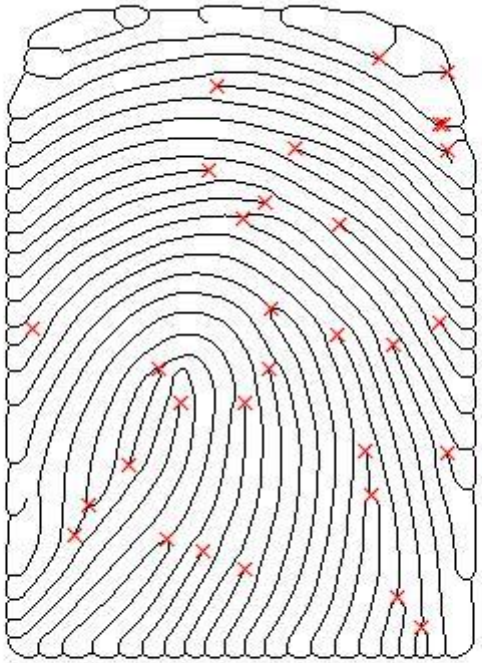


Tiempo de computo de la extracion : 0.099504

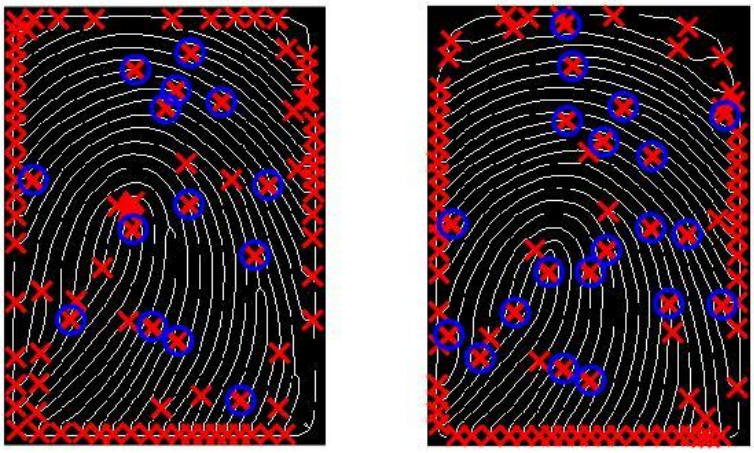
Final validated set



Tiempo de computo de la validacion : 0.0097764

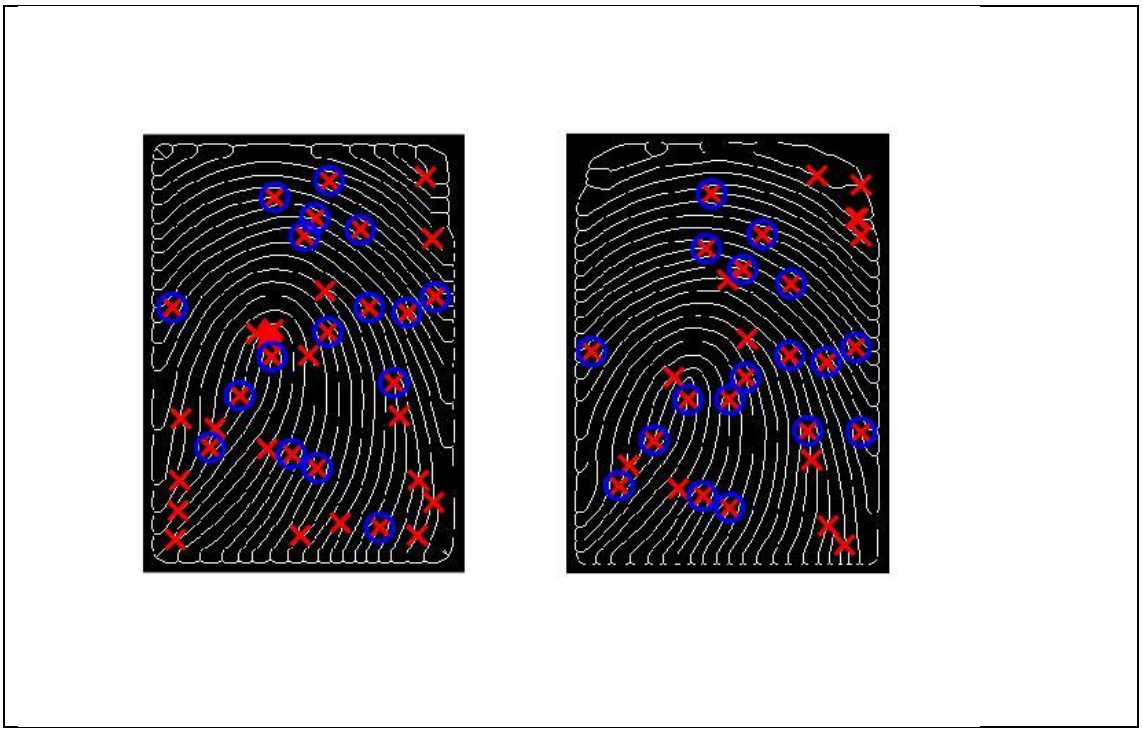
6.a) Execute the code corresponding to the **Minutiae Validation** for *window*=5 and *margin*=5. Paste the resulting image including the minutiae extracted (red crosses) and validated (blue circles) of both fingerprints.

On image observed below, the significant minutaes extracted are remarked with blue circles. This makes for everybody an extremely easy recognition of the most important features of each fingerprint, cleaning up the results and avoiding some possible fake detections.



6.b) Execute the same code but with the optimal values of parameters *window* and *margin*. Paste the resulting image below.

With this new and optimized version of the image, we can observe how almost every minutae is represented with a blue circle surrounding it. This is significant because is much easier to recognize both images are the same fingerprint, taken from different spots or with different angles or positions.



6.c) Do you think it is a good idea to include the **Minutiae Validation** module? Justify your opinion.

Yes, it is useful. This process helps identify the most relevant minutes and isolating some wrong detected minutaes, making the previous parameter selection more standard, although the better input, the better output.

At the same time, it helps to the recognition of different fingerprints, making easier this complex work. In this exact case, it is observed how both images represent the same fingerprint slightly displaced.

With all the previous exercises done correctly you can obtain a mark up to 7 points out of 10.

Extra work: If you want to obtain a markup to **10 points out of 10** you should complete the following:

In folder "/ddbb" you have 20 fingerprint images. 19 of them are labeled with the subject identity (e.g., H0001), and 1 is Unknown. Search for the identity of the Unknown fingerprint in the set of 19 labelled reference fingerprints. You can use the provided code "identification_1_19.m" as basis. Paste here the resulting ranked list of scores of the Unknown fingerprint with respect each one of the 19 reference fingerprints.

The code and file: extract_minutiae are attached at the corresponding zip. The result of the code indicates the searched fingerprint is the one of the subjects 13: H13.

This is obtained by computing all the Hough values between the unknown fingerprint and all the fingerprints from the databases. The maximum value from all those computed is the searched answer.