Practical 4

Ole André Hauge

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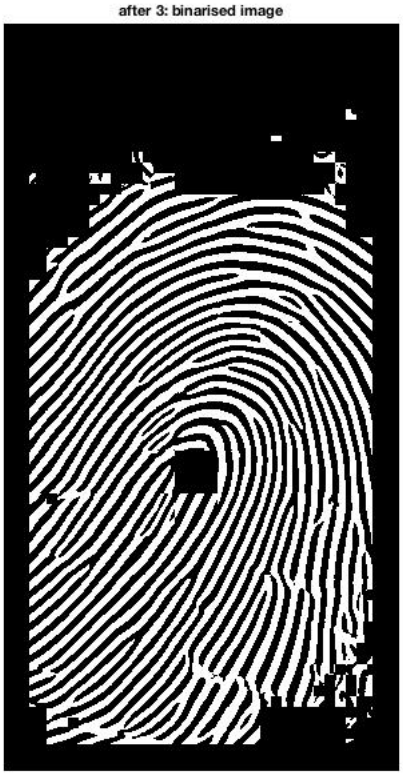
Order of the steps in the pipeline

1. The steps in the above pipeline are in a distinct order.

   (a) [5 points] Can we change the order of enhancement (considering Step 3-6 as an enhancement block) and binarization (Step 7)? Try to move Step 7 right after Step 2, and see the difference.



Answer: We can do binarization of the image before we do the enhancement. Whether we should do it is another question. The result is a binary representation of the normalized image from step 2. The following changes are visible (result from step 7 run before step 3, compared to "normal"):

i. More noise (white) surrounding the fingerprint. It makes it somewhat easier to see where the edges of the fingerprint are compared to the "normal" image where the edges seem more "floating" and pixelated, from a purely visual perspective. A computer program might find it problematic as there are both a great white area and a black area surrounding the fingerprint.

ii. The ridges are more granular, making it hard to identify the different minutiae points and

ridges. However, it is not missing the center of the loop in the fingerprint, but tuning the normal image enhancement variables will probably fix this problem.

iii. The white spaces between the ridges are enlarged and overlap at several points.

The total of these factors gives an image that is of poorer quality and sharpness where it is harder to identify features and ridges.

(b) [5 points] Provide arguments to support your observation

Answer: The binarization of an image is done by converting the value range of the original image to a value of 0 or 1 given a threshold, effectively producing a black and white image. The different enhancement steps result in an image that has less noise, which again results in a cleaner/sharper binarized image as it is easier to differentiate between the values in the image.

We can skip or neglect different steps in the enhancement process, like "ridge orientation estimation" or "Ridge region masking", as we will still have an image that can be binarized. However, this will result in a lower quality image, thus resulting in a binarized image of lower quality.

The white noise surrounding the fingerprint is probably the result of not applying the mask to the processing of the image, as the mask would have omitted this white noise as not relevant for the binarization process.

The granularity and white spaces would be improved by applying one or all of the following:

i. Pixel intensity normalization - The difference between 0's and 1's would be clearer.

ii. Ridge orientation estimation - The location of the ridges would make it easier to orient and locate the actual ridges.

iii. Ridge frequency estimation - Help with the clarity of the image.

iv. Ridge region masking - Help differentiate between different ridges.

v. Filtering - Overall clarity.

The lower quality of the binarized image makes it harder to properly extract the features from the fingerprint as certain ridges might get thinned too much or ridge endings might appear where they are not.

The enhancement steps are, as we see of this experiment, there to enhance the image and produce a better result at the end.

Delete Sensitive Data

2. The fingerprint images collected in the second practical were shared between the on-campus students for the purpose of solving the tasks in Practical 03 and Practical 04. As you have now completed Practical 04 you shall delete the data from your colleagues. (you can of course keep your own data).

   (a) [0 points] I do confirm that I have removed the fingerprint images from other on-campus students as I have completed Practical 04.

   Answer: I confirm that I have removed the fingerprint images from other on-campus students as I have completed Practical 04.

   As I'm not capable of signing the document I hope that my student name and number is enough:

   Ole André Hauge / 538916