# Cryptographic passports \& biometrics, summer 2009 <br> Michael Nǘsken, Konstantin Ziegler 

## 12. Exercise sheet

Hand in solutions until Monday, 20 July 2009.

Any claim needs a proof or argument. Answer in complete sentences and your own words. A verbatim quote is never a complete answer.

Exercise 12.1 (More about large scale automation). (3+2 points)

Read the FBI pages about IAFIS.
(i) How large is the archive now?
(ii) How many requests per day are made? Or:
(iii) How is the archive accessed?
(iv) How reliable is the system? What are the false accept and reject rates?
(Name a source for these rates, please, if you find that.)
(v) How long does a single search take? (CPU? turn around time?)

## Exercise 12.2 (FVC).

The first Fingerprint Verification Competition was held in 2000, see their webpage under http://bias.csr.unibo.it/fvc2000/.
(i) What do you have to provide in order to compete?
(ii) Pick three algorithms and describe why and in which situation you would choose one over the others based on the results, see http://bias. csr.unibo.it/fvc2000/results.asp.
(iii) What is the reason that "For a correct interpretation of the results, Avg EER alone is not an exhaustive metric, but Avg REJ ENROLL should be also taken into account"?

Exercise 12.3 (Gabor-Filtering).
(14+4 points)
We want to observe some effects of Gabor-Filtering on the fingerprint given on http://en.wikipedia.org/wiki/File:Fingerprintonpaper.jpg.

You will find a image manipulation program helpful, that is able to zoom in on specific pixels and output their respective greyscale value. To measure the intensity in $x$-direction of a specific pixel A, consider the 8 neighbouring pixels and weigh their greyscale according to the following scheme:

| -1 | 0 | 1 |
| :---: | :---: | :---: |
| -2 | $A$ | 2 |
| -1 | 0 | 1 |

The sum of these values gives $I_{x}$ which is a suitable approximation to the derivative $\partial I / \partial x$. Turning the scheme by 90 degrees gives the weights for $I_{y}$.
(i) Choose 4 pixels in the picture at random and compute the parameter $\theta$ for the Gabor-Filter by

$$
\begin{equation*}
\theta=\arctan \left(\frac{I_{y}}{I_{x}}\right) . \tag{12.4}
\end{equation*}
$$

Draw a corresponding arrow into the image.

We also want to consider a more refined choice of $\theta$ according to

$$
\begin{equation*}
\theta=90^{\circ}+\frac{1}{2} \arctan \left(\frac{2 G_{x y}}{G_{x x}-G_{x y}}\right) \tag{12.5}
\end{equation*}
$$

where

$$
G_{x y}=\sum_{-w / 2 \leq h, k \leq w / 2} I_{x}\left(x_{A}+h, y_{A}+k\right) \cdot I_{y}\left(x_{A}+h, y_{A}+k\right)
$$

at the point $A$ with coordinates $\left(x_{A}, y_{A}\right)$.
(ii) Examine the relation between (12.4) and (12.5) for the simple case $w=0$.
(iii) Write a programm in a language of your choice which computes $\theta$ according to (12.5) for a reasonably large frame size $w$, e.g. $w=15$. Use it to add "more precise" arrows at the points established in Exercise 12.3(i). Compare the quality of the two results.

## Exercise 12.6.

An online Gabor filter simulation is available on http://matlabserver. cs.rug.nl/cgi-bin/matweb.exe.
(i) Use as input image the fingerprint s.png and fiddle with the parameters to achieve an output that qualifies as fingerprint.
(ii) Use as input synthetic1.png and play with the parameters to make the vertical lines disappear without "ruining" the skew lines.

