National Institute of Standards and Technology
U.S. Department of Commerce

Federal Office for Information Security

Candidate Features for Quality Assessment

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secunet

Quality Features For NFIQ 2.0

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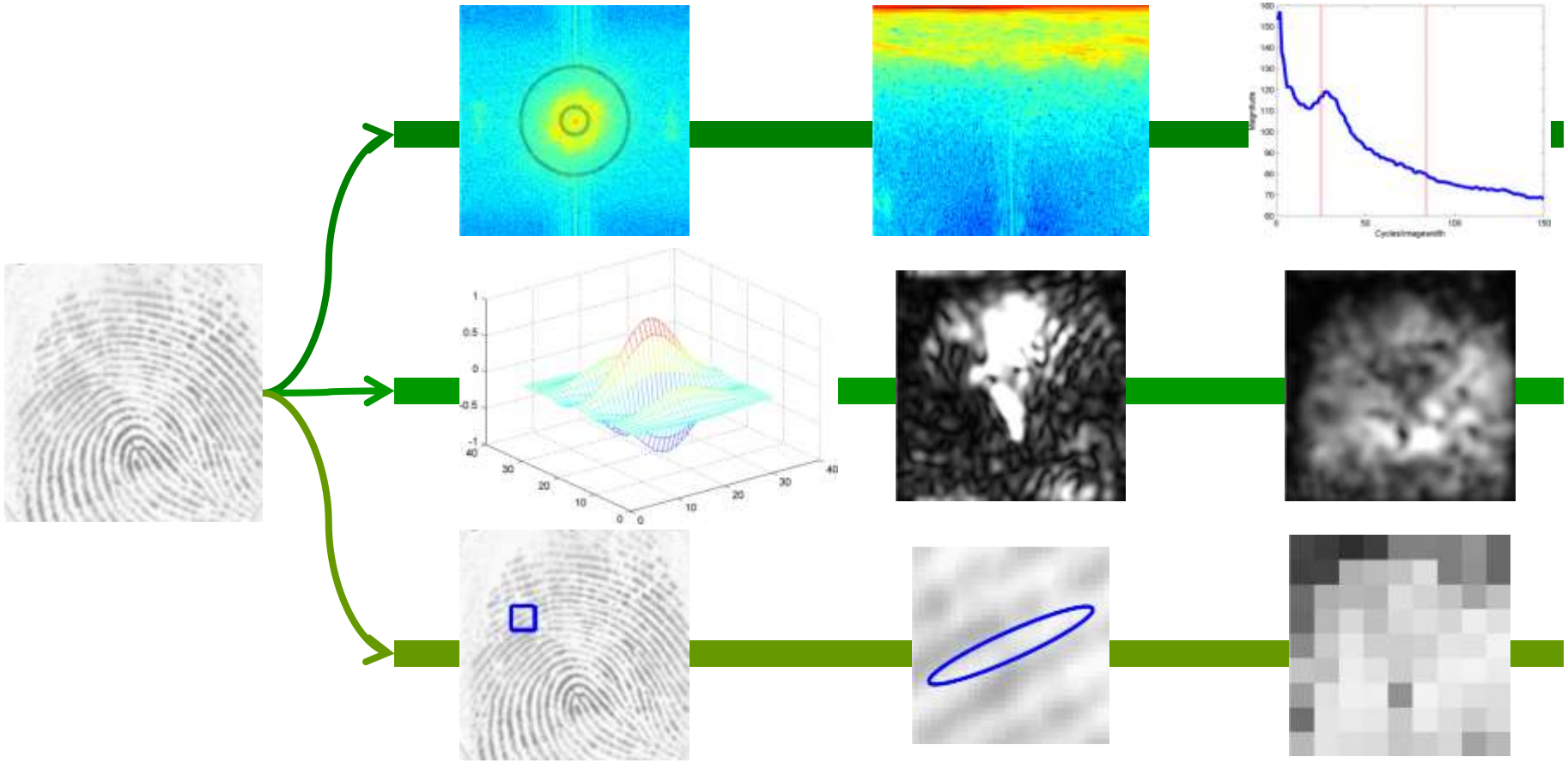
- Requirements
  - Based on publically available algorithms
  - Standardized interface (inputs and outputs)



Implemented Quality Features

- More than 30 features identified and tested on multiple datasets
  - NFIQ
  - Implemented from ISO/IEC TR 29794-4
    - Frequency Domain Analysis
    - Local Clarity Score
    - Orientation Certainty Level
    - Orientation Flow
    - Radial Power Spectrum
    - Ridge Valley Uniformity
  - Gabor filter
  - Ridge line count
  - Gabor (Shen et al., Quality Measures of Fingerprint Images, 2001)
  - Minutiae count in region of interest
  - FingerJetFX

Feature Example

Orientation Certainty Level

- See NFIQ 2.0 project page at http://www.nist.gov/itl/iad/ig/development_nfiq_2.cfm

- ISO/IEC 29794-4:2010
- Block wise approach

```
function [orientationCertaintyLevel] = compOcl(im, mask
    allfun = inline('all(x(:))');
    [rows cols] = size(im);
    eblksz = ceil(sqrt(sum(v1sz.^2)));
    blkoffset = ceil((eblksz - blksz)/2);
    mapsize = fix(([rows cols] - (eblksz - blksz))./blk
    maskBseg = false(mapsize);

    ocls = zeros(mapsize);




end
```

OCL input parameters		
lame	Default	Description
I	-	Input image
B_h	32	Block height in pixels
B_w	32	Block width in pixels
$mask$	-	Segmentation mask

```
}
```

Orientation Certainty Level

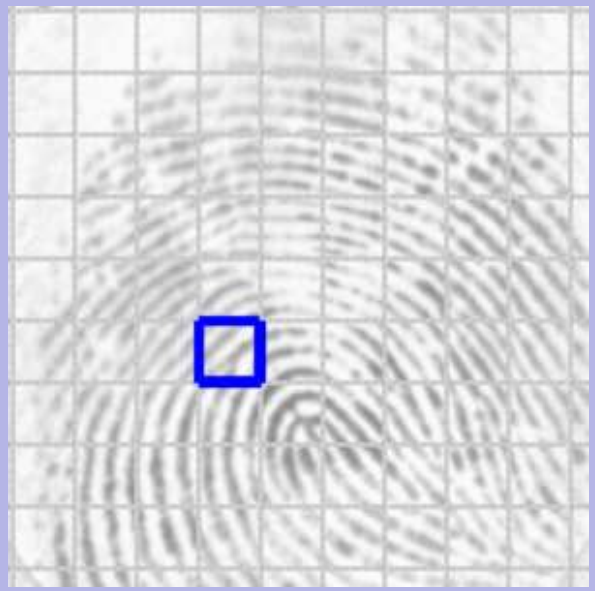
Algorithm → Covariance

1. Compute the intensity gradient of each block

$$[dx \quad dy] = gradient(B)$$

2. Compute the covariance matrix from the gradients

$$C = \frac{1}{N} \sum_{N} \begin{matrix} dx \\ dy \end{matrix} [dx \quad dy] = \begin{matrix} a & c \\ c & d \end{matrix}$$



Orientation Certainty Level

Algorithm → Eigenvalue computation

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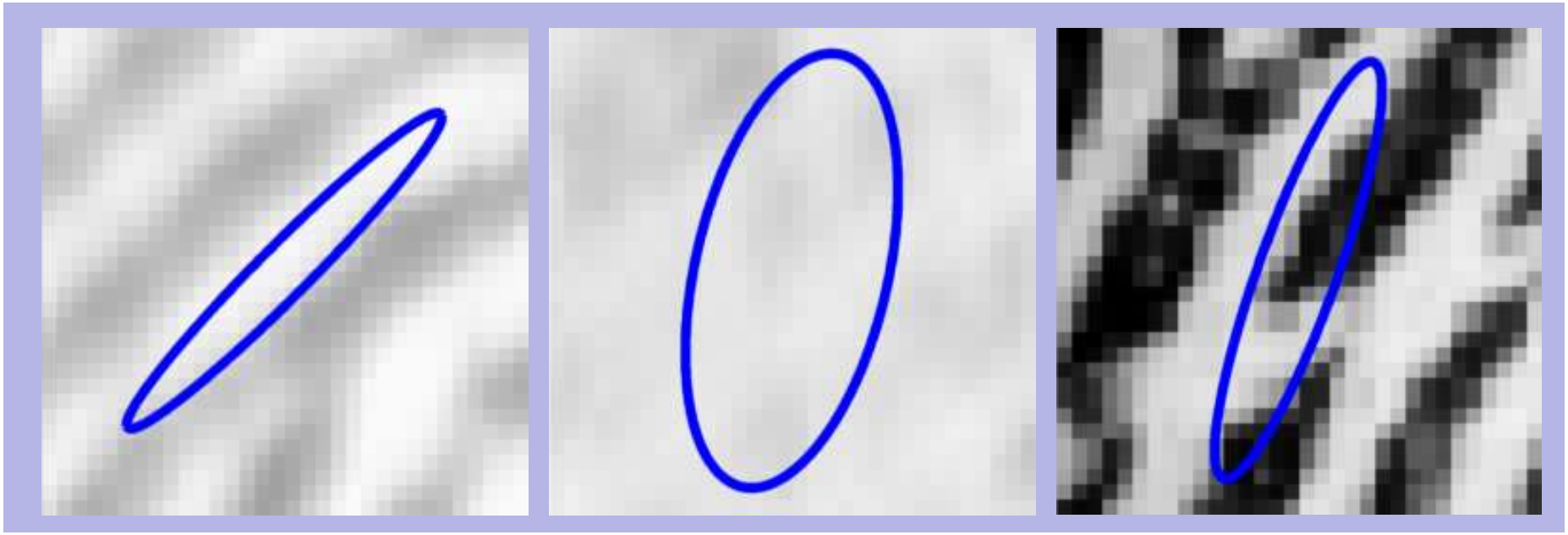
3. Compute the eigenvalues to obtain OCL for each block

$$\lambda_{min} = \frac{a + b - \sqrt{(a-b)^2 + 4c^2}}{2}$$

$$\lambda_{max} = \frac{a + b + \sqrt{(a-b)^2 + 4c^2}}{2}$$



Orientation Certainty Level

Algorithm → Computing the quality score

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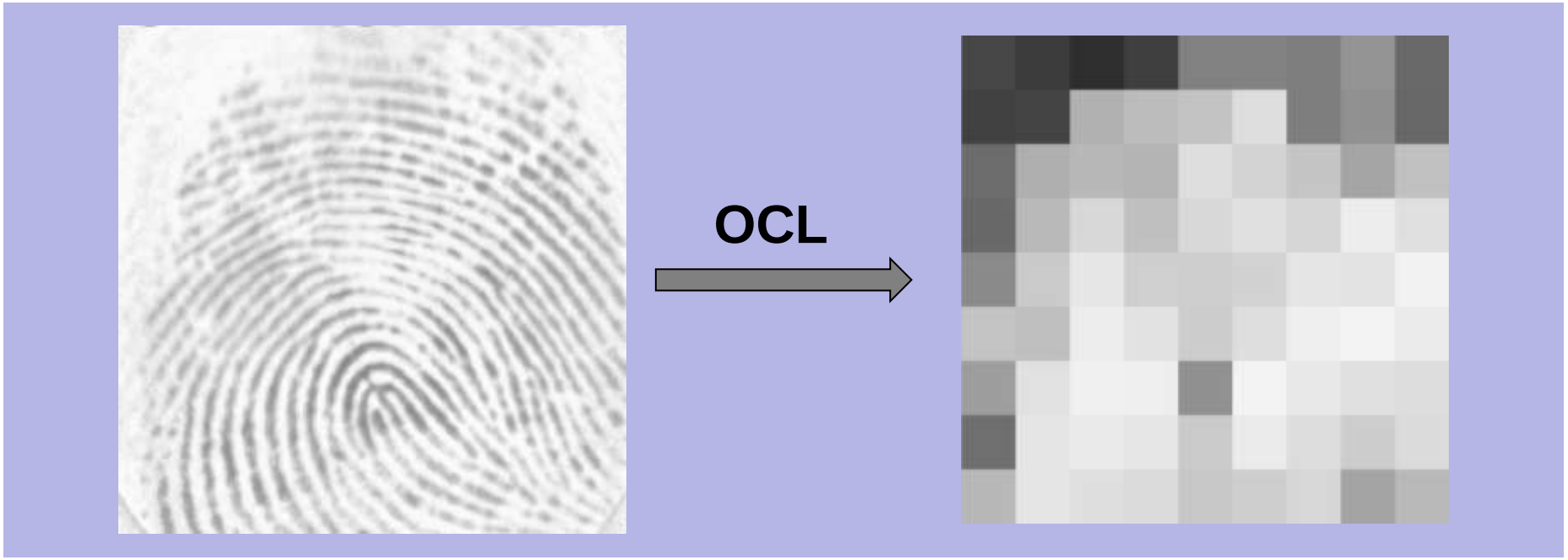
- Local orientation certainty level
  - A ratio in the interval [0, 1] where 1 is highest certainty level and 0 is lowest.

$$OCL = 1 - \frac{\lambda_{min}}{\lambda_{max}}$$



Shaping of Gabor filter according to detected ridge-line frequency

- Feedback from previous workshop at IBPC ’12 to use:
  - Dynamic filter bank based on detected ridgeline frequency
  - In progress using ridgeline counting and detected frequency peak

Actionable Quality

Providing more than a quality value

- Detectors
  - Centeredness (based on singularity position)
  - Wetness/pressure
  - Completeness
  - Ghostprints

- Motivation:
  - “It would be useful to have a detector for too dry/wet fingers, too low/high pressure, and out-of-center fingerprints.” – Greg Cannon during IBPC ’12 NFIQ 2.0 workshop
  - Reply back then was: “Whether this can be detected or not depends on the training data. Contributions of finger images that are known to have low/high pressure etc. are welcome”.

Data collection for wet/dry detection
Overview

- 5 fingerprint sensors (optical)
- 33 subjects
- 4 impressions/finger/sensor
- 6600 images total
- 4 types of treatment
  - No treatment
  - alcohol-dried
  - crème-moisturized
  - water

Data collection for wet/dry detection
Examples

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- Objective measurement of skin moisture level

62.5%

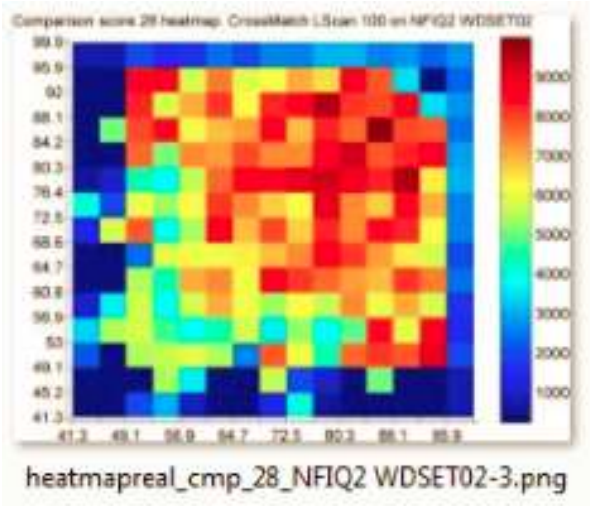
84.6%

99.9%

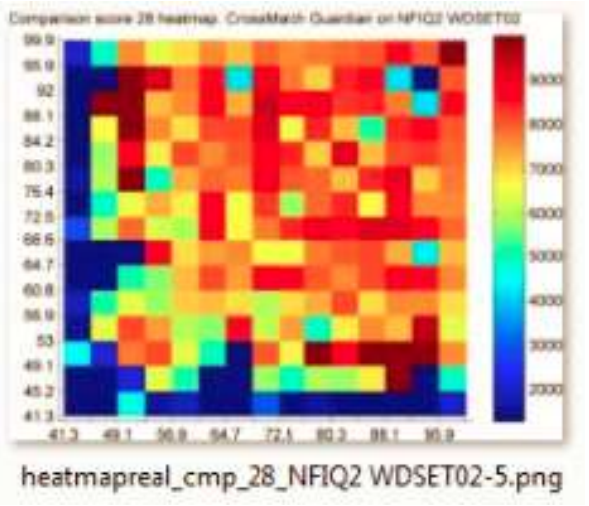
Observations on wet/dry impressions

- Wet fingerprints are generally handled well by recent sensors
- Dry fingerprints cause degradation in comparison score

Older generation sensor



New generation sensor



See master thesis by Marek Dusio (DTU) – to be published in June 2013

NFIQ 2.0 Lite

- Motivation:
  - Execution speed of feature extraction is important in some applications (even though processors are getting faster and faster). Aim at 125–150 ms for inclusion of quality assessment into auto-capture loop of sensors. – IBPC ‘12
- Potential solution:
  - Pre-compute a lookup table which can speed up the quality assessment

NFIQ 2.0 Lite
Machine Learning approach

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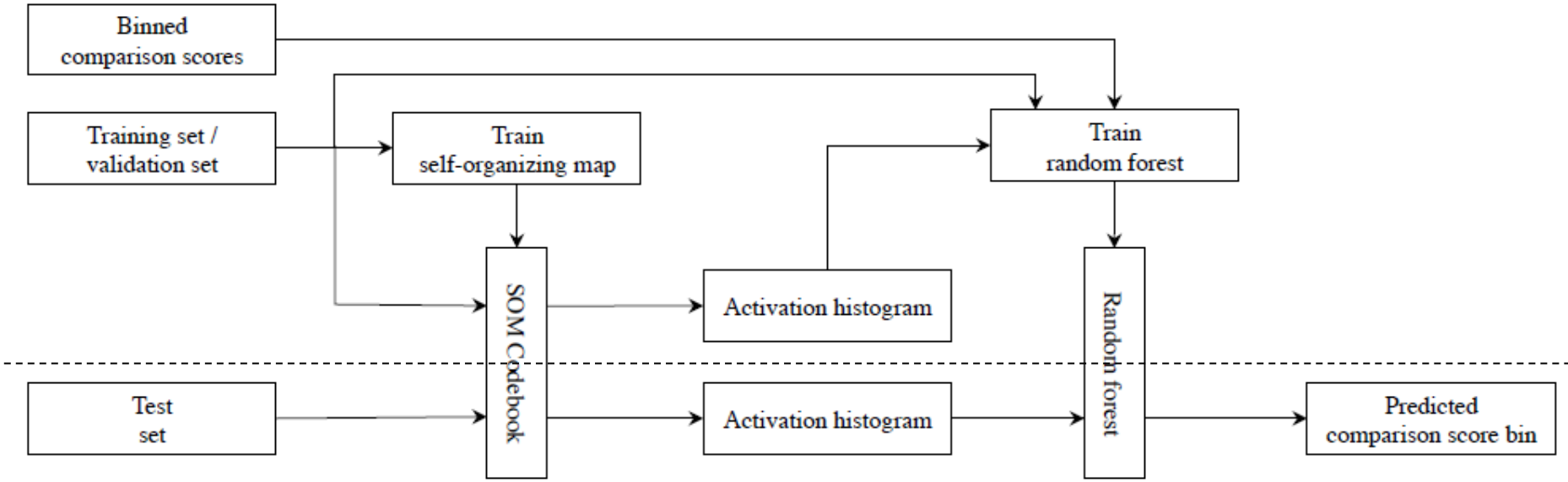
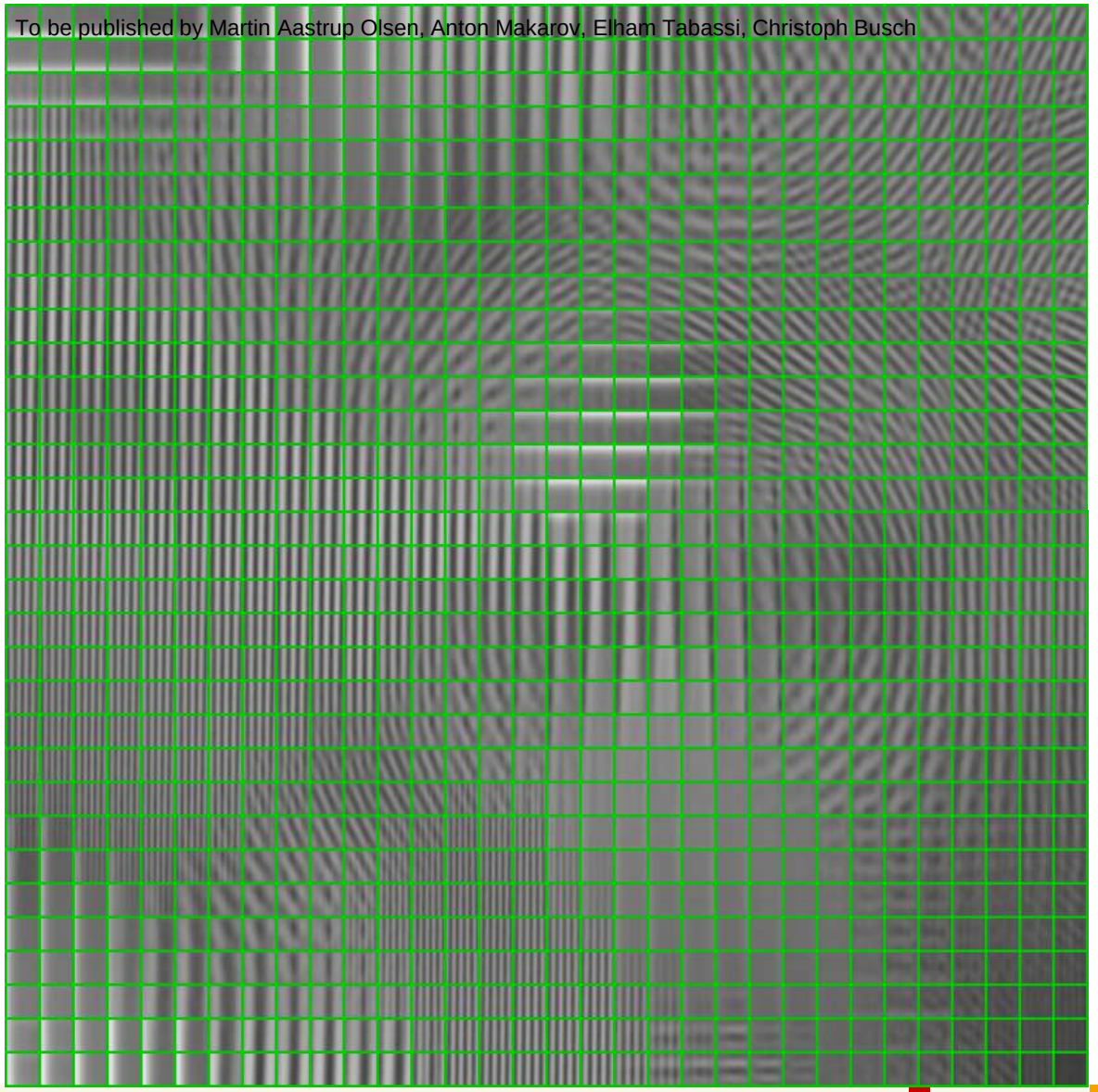
- Two stage process
  - Clustering using Self-Organizing Map
  - Prediction using Random Forest

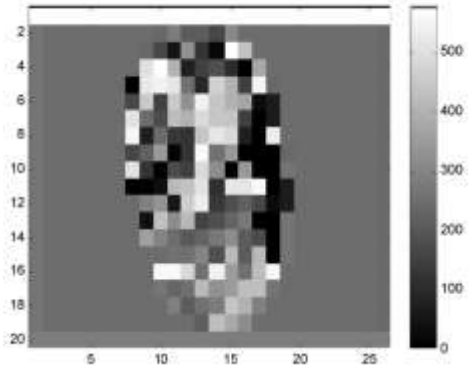
To be published by Martin Aastrup Olsen, Anton Makarov, Elham Tabassi, Christoph Busch

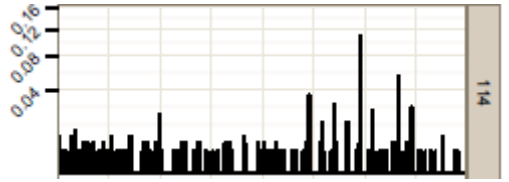


SOM example



Blocksize: 24 x 24 px
SOM units: 32 x 32





SOM activation histogram

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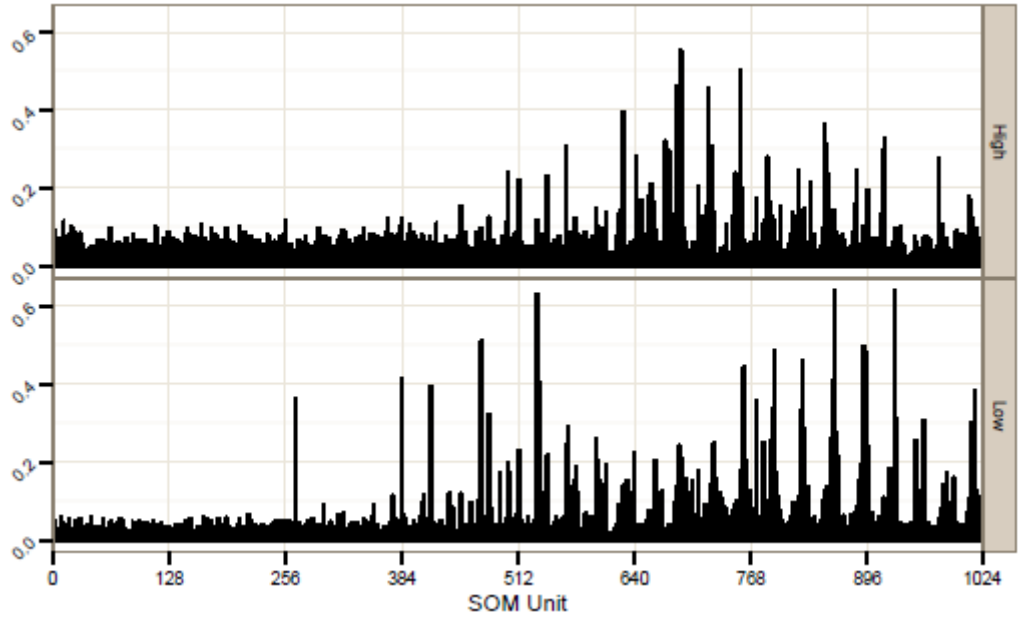
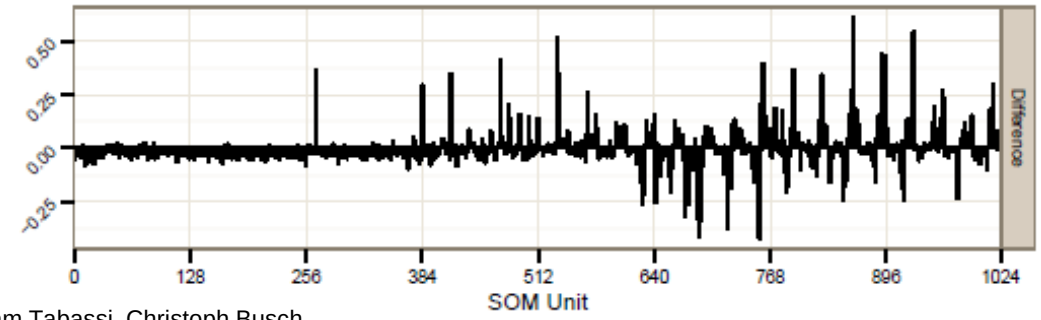
- 64 images with highest comparison score
- 64 images producing false non-match at FNMR = 10^-4



- Difference between histograms.



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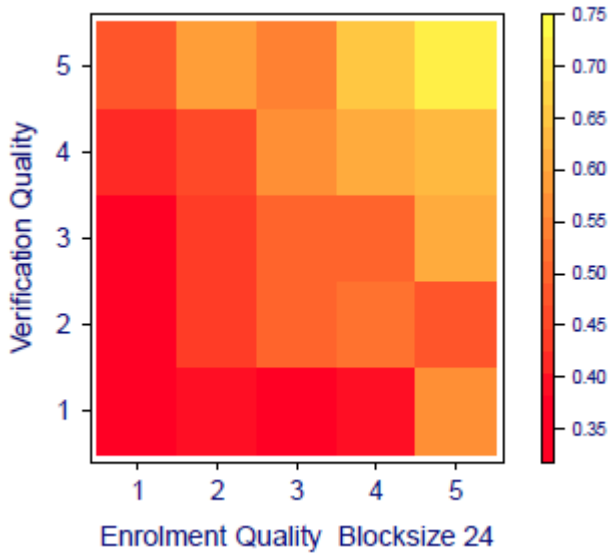
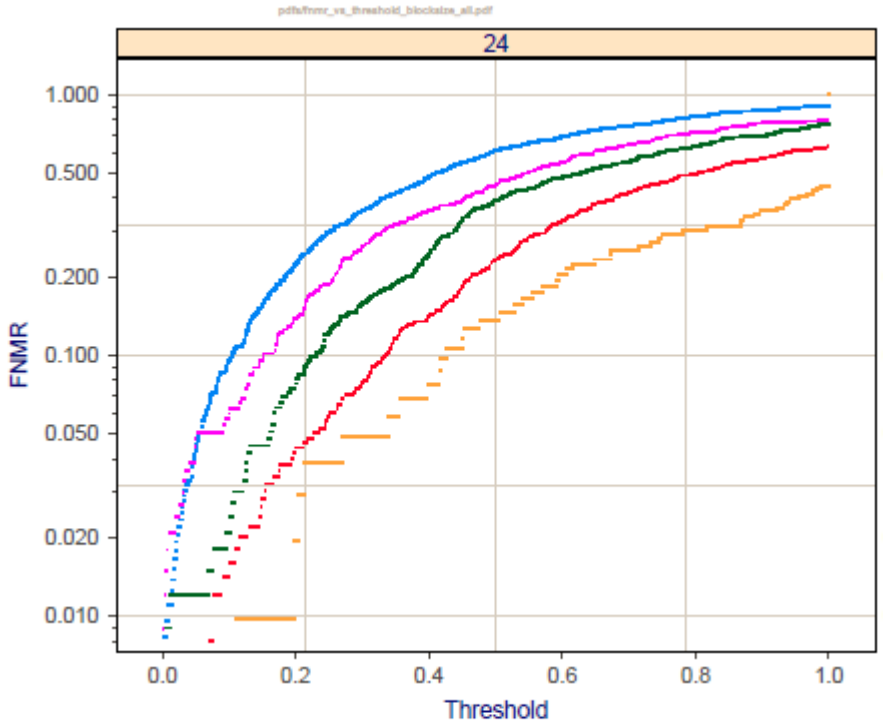
Performance indication

- FNMR vs. score threshold for each level of quality





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