secunet Security Networks AG

Experiences with the retraining of NFIQ

Gaithersburg, March 1st, 2010
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## Agenda

1. Why retrain NFIQ?

2. Training approach and results

2. Wrap-up / discussion of next steps
## Why retrain the NFIQ?

<table>
<thead>
<tr>
<th>Widely used reference</th>
<th>Potential improvements</th>
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<td>Recognized as a reference in fingerprint quality estimation</td>
<td>Strange behaviour in some cases</td>
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<td>Used for ePassport application e.g. in Germany</td>
<td>- E.g. quality values for fingertips only</td>
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<td>Used for Visa application e.g. in Germany</td>
<td>Increase speed</td>
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<td>Often coded as quality estimate in fingerprint reference data</td>
<td>More granular quality estimation</td>
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<td>Seen as a reference compared to alternative approaches</td>
<td>- Definition of more classes</td>
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<td>- More homogenous distribution of classes</td>
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<td>Better suited training base for the target application</td>
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<td>- E.g. no rolled or paper scanned fingerprints for eDocuments</td>
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General Approach

Statistical Evaluation

- Match Scores
- Norm. Match Score
- Quality Class

Estimation by Neural Network

- Image Features
- Estimated Quality Class
Thoughts on influences and parameters for the retraining

- rolled / plain sensors
- no. of imprints per finger
- matching algorithms
- size of the similarity matrix
- error handling
- definition of norm. match scores
- fusing matching algorithms
- number & size of classes
- selection of features
- no. of features
- extraction algorithm
- size of network
- error function
- network optimization parameters

Main changes in BSI/secunet retraining

- Different database (live scan, plain)
- Up-to-date matcher
- Increase no. of classes (10)
Data basis

- Original NFIQ used several databases
  - Both live-scans and inked imprints → Inked imprints not relevant for border control
  - two imprints per finger → only one genuine score per finger
  - 50% as training set, 50% as test set

- We used 9 live-scans of 8784 fingers, captured with 3 different sensors
  - 8 genuine scores per finger
    → allows careful consideration of genuine score deviation by robust measures (15% quantil)
  - Computation of 450 match scores per imprint

- We used 5 matching algorithms
  - NIST, Neurotechnology, L1/Identix, Dermalog, NEC
  - NEC SDK returns match score „0“ in case of non-match (internal threshold)
    → match score statistics less significant

- 5 classes, resembling original NFIQ

![Distribution of NFIQ values](secunet)
**Result**

- Impact of neural network training parameters were small.
- Evaluation on test-set shows slight improvement.

Det curves for fingerprint selection based on NFIQ+ and NFIQ algorithms.

As reference, DET curve of selector based on real classes.

Optimal classifier for given class definition.
Promising optimization potential

- adapt variety of sensors
- exact scores (NEC)
- more matching algorithms
- definition of normalized comparison score
- more classes
- better or different features
- error function (approximation, not classification)

- fingerprint data basis
- calculate comparison scores
- define NFIQ classes
- image feature extraction
- neural network training

- DET curves show: 10 classes bear more potential than 5
- Optimize class definition first
- Feature vector definition could have great optimization potential
  - E.g. apply neural network for quality assessment of minutiae
Leasons learned

- Retraining is possible..
- But: No ready to use toolbox

- Documentation should be extended for NFIQ 2.0
  - Detailed documentation of the training process is missing
  - Information needs to be gathered by source code examination
  - Results of the original NFIQ training process are not available in detail
    - would be useful for comparing results

- Big improvement of NFIQ performance seems to be possible
  - More examination necessary
Wrap-up

- NFIQ is highly needed
- Clear potential for optimization
- NIST's ideas for NFIQ 2.0 highly appreciated
- Vendor-independent but modular NFIQ upgrade suggested

Looking forward to an interesting discussion
Thank you for your attention!

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