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Contactless Fingerprint Quality Assessment

Mobile ContactLess Fingerprint Image Quality (MCLFIQ)

Laurenz Ruzicka, Jannis Priesnitz

Mobile ContactLess Fingerprint Image Quality (MCLFIQ)

Quality is defined as "being suitable for the intended purpose"

- Mapping of a biometric signal to a numerical value
- Crucial for systems accuracy and user comfort
- Utility based sample quality assessment (ISO/IEC 29794-1)
  - Character – Quality of inherent biometric source
  - Fidelity – Similarity of sample to source
  - Utility – Quality of sample, combination of Character & Fidelity
- MCLFIQ
  - Based on NFIQ 2 framework
  - Use NFIQ 2 features standardized in ISO/IEC 29794-4

MCLFIQ: Mobile Contactless Fingerprint Image Quality -
Jannis Priesnitz; Axel Weißenfeld; Laurenz Ruzicka; Christian Rathgeb; Bernhard Strobl; Ralph Lessmann; Christoph Busch
https://doi.org/10.1109/TBIOM.2024.3377686

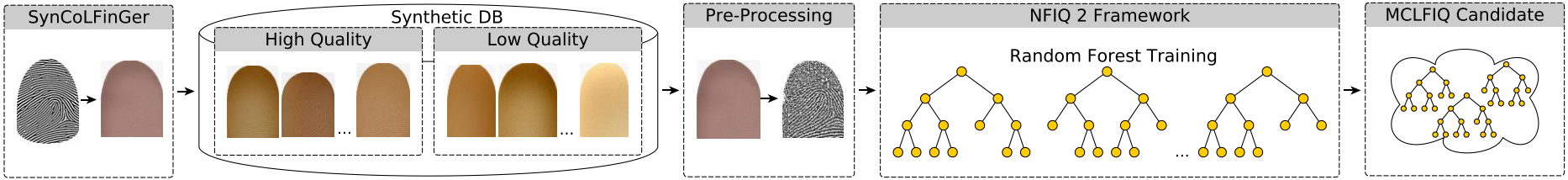
Proposed MCLFIQ Method

Training

- Synthetic database generation
- Database pre-processing
- Random forest training

Testing

- Quality score computation
- Comparision score computation
- EDC calculation



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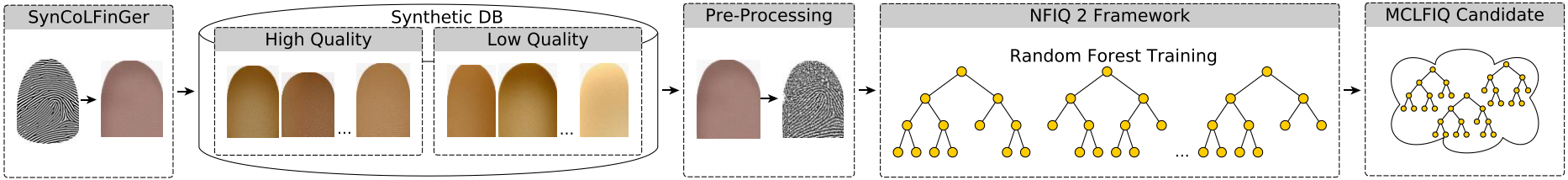

SYNthetic COntactLess FINgerprint GEneratoR (SynCoLFinGer)

- SFinGe to generate ridge line characteristics of 500 dpi live scanned fingerprint
- Applies deformation function to simulate contactless capturing
- Scale-able addition of subject related characteristics
  - Skin colour approximation
  - Skin tone variation
  - Regions of low contrast
- Scale-able addition of environmental characteristics
  - Shadow and illumination variation
  - Dirt
  - Sensor noise
- Results in a synthetic, contactless fingerprint sample with variable quality [0, 100]

SynCoLFinGer: Synthetic contactless fingerprint generator - Jannis Priesnitz; Christian Rathgeb; Nicolas Buchmann; Christoph Busch
https://doi.org/10.1016/j.patrec.2022.04.003

Synthetic Fingerprint Database & Pre-processing

- Use SynCoLFinGer to generate samples of different quality [0, 100]
- Conversion to grayscale followed by Contrast Limited Adaptive Histogram Equalization (CLAHE)
- Normalize to fixed ridge-line frequency of ~9 pixels

NFIQ 2 Framework

- Maintained by Maintained by ISO/IEC JTC1 SC37
- 40k synthetic samples
  - 30k for training
  - 10k for validation
  - 50% high-quality, 50% low-quality
- Create random forest with 100 trees
  - Maximum depth of 25 for each tree
  - 10 randomly sampled variables as split candidates
  - Minimum sample count per leave of 2
  - Tree pruning
- Outputs class membership with according probability
- MCLFIQ score is probability of high-quality class x 100

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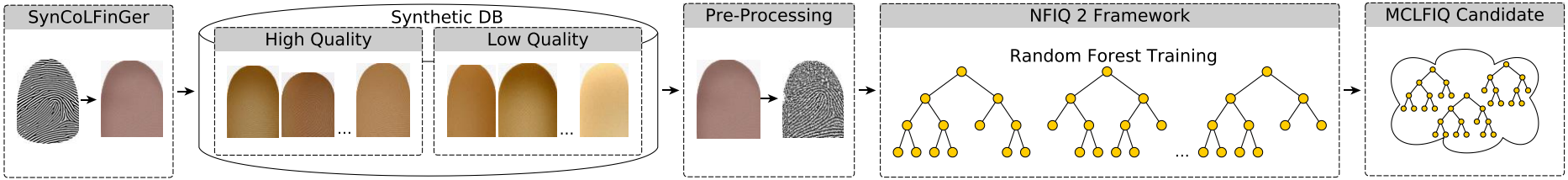

Baseline Quality Scores & Recognition Workflows

Baseline Quality Scores

- NFIQ 2.2
- AIT Sharpness
- BRISQUE

Recognition Workflows

- COTS
  - IDKit SDK (Innovatrix)
- Open source
  - FingerNet & SourceAFIS
  - MindTCT & BOZORTH (NBIS)

Experimental Setup

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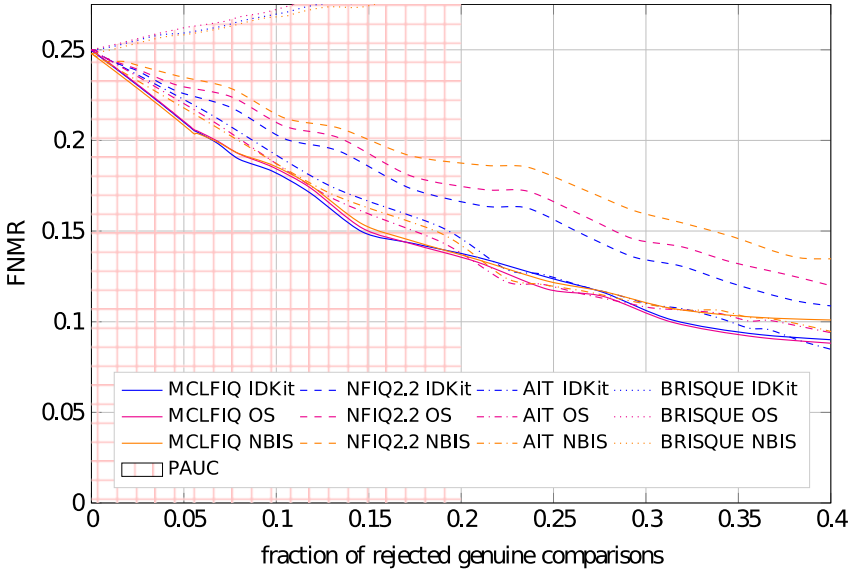
Databases

- AIT: mobile, contact-based
- ISPFDv1: contactless, contact-based
- HDA: constrained, unconstrained, contact-based
- FVC2006: DB2, DB3

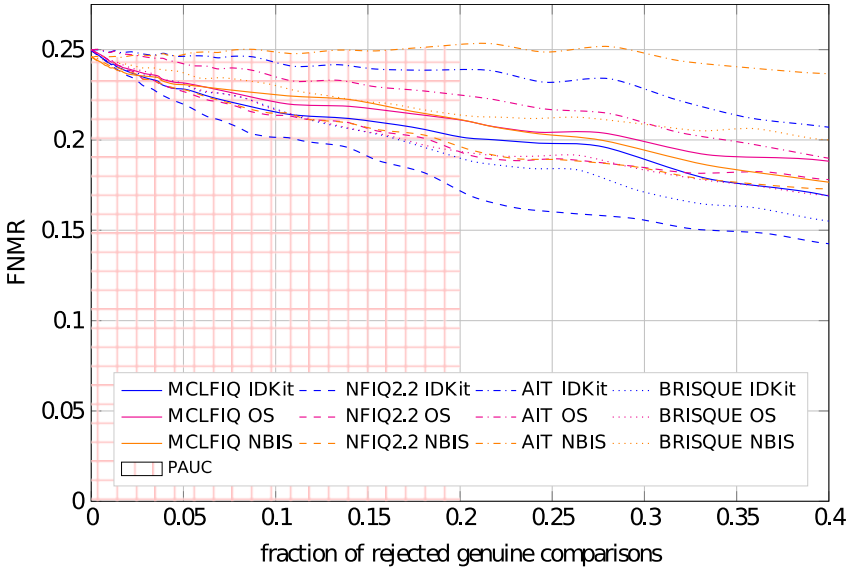
Metrics

- Error vs. Discard Characteristic (EDC) curve
- EDC Partial Area Under Curve (EDC PAUC)
  - In the range [0 – 0.2]

Results



Contactless (ISPFDv1 Natural Outdoor)

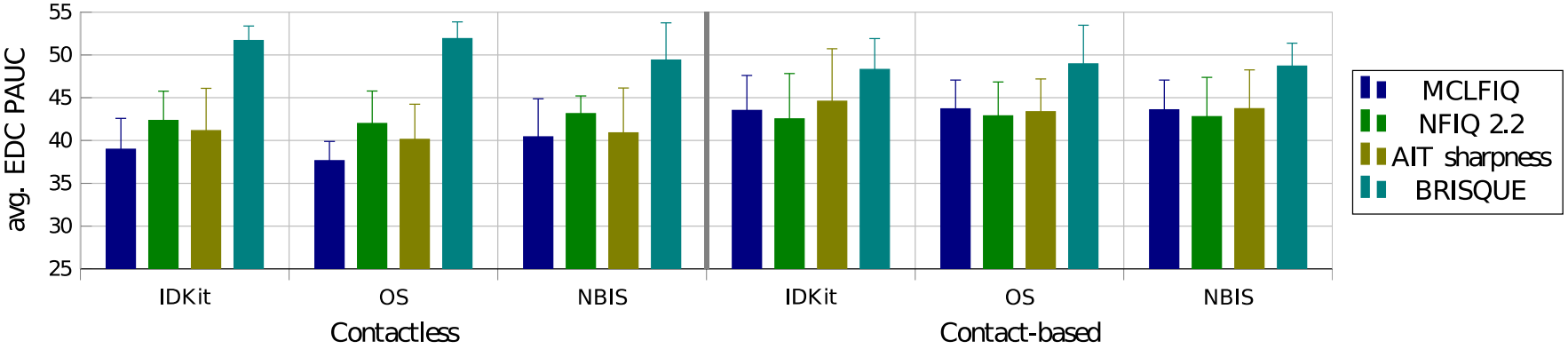


Contact-based (FVC2006 DB2)

Note: Lower values indicate better performance

Results Summary

- MCLFIQ: Lowest EDC PAUC for contactless subsets
- NFIQ 2.2: Lowest EDC PAUC for contact-based subsets
- No significant difference between recognition workflows



Conclusion & Outlook

Summary

- BRISQUE shows subordinate performance
- No significant difference between recognition workflows
- MCLFIQ shows improved performance and robustness

Conclusion

- NFIQ 2 framework is well-suited for alternative recognition workflows
- MCLFIQ effectively predicts the quality of mobile contactless fingerprint samples
- Suggestion: Consider MCLFIQ as starting point for a new standard

Limitations

- Synthetic training database
- Size and diversity of test database

Future Work

- Analysis of additional features
- CNN-based quality assessment

Outlook & Possible Cooperations

Fingerprint Mosaicking Artifacts

- Combination of multiple fingerprint samples into master sample
- Slight misalignments or distortions introduce artifacts
- Impacts recognition performance (up to doubling of Equal-Error-Rate)

Artifact Detection Approach

- Synthetic artifacts for training as self-supervised training signal added to real fingerprint samples
- Deep learning-based approach
- Proposal of a mosaicking artifact score

Experiment & Results

- Trained separately on 245k contactless & 26k contact-based samples
- Exceptional performance (F1 score: 0.99, false match rate: 0.06%)

Problems

- Require real-world artifact data to test model & ideally also for fine-tuning

Outreach

If you have mosaicking artifact data and want to cooperate on this novel approach, please reach out: Laurenz.Ruzicka@ait.ac.at !

Towards Fingerprint Mosaicking Artifact Detection: A Self-Supervised Deep Learning Approach -
Laurenz Ruzicka; Alexander Spenke; Stephan Bergmann; Gerd Nolden; Bernhard Kohn; Clemens Heitzinger
https://arxiv.org/abs/2501.05034

MCLFIQ Paper: https://ieeexplore.ieee.org/document/10473152

MCLFIQ Model: https://jannis-priesnitz.de/wp-content/uploads/2025/03/MCLFIQ_model.zip

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THANK YOU!

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