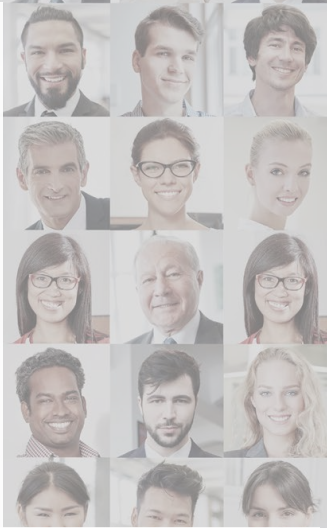
Warning: Copyright Notice



Contactless Fingerprint Sample Quality: Prerequisites for the Applicability of NFIQ2.0

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Hochschule Darmstadt, ATHENE, da/sec Research Group

virtual, June 16, 2021

Contactless Fingerprint Sample Quality: Prerequisites for the Applicability of NFIQ2.0

- Is NFIQ2.0 a predictor for contactless fingerprint images?
  - NFIQ2.0 works well on contact-based datasets.
- Which prerequisites must be satisfied so that NFIQ2.0 can assess the quality?
  - Huge difference between contactless and contact-based data.

Agenda

Quality Assessment on Fingerprint Data

Considered Datasets

Preprocessing Pipeline

Evaluation Method

Results

Interpretation

Analysis on a self-captured Database

Quality Assessment on Fingerprint Data

Contact-based and contactless Fingerprint recognition

Figure: Contact-based sample

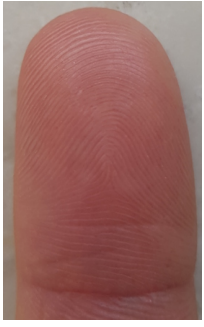


Figure: Contactless sample

Quality Assessment on Fingerprint Data

Fingerprint Quality Assessment

- Crucial part for a high biometric performance
- Function that maps an input image to a numeric value
- NFIQ2.0
  - Widely used for contact-based fingerprints
  - Uses various different features (eg. size, contrast, minutiae count)
  - Random forest classifying the sample quality based on the different features

Figure: NFIQ2.0 Score: 82

Figure: NFIQ2.0 Score: 9

Considered Datasets

Considered Performance Evaluation Datasets

- Fingerprint Verification Competition (FVC2006)
- MCYT fingerprint subcorpus
- Hong Kong Polytechnic University contactless 2D to contact-based 2D fingerprint images database version 1.0 (PolyU)
- IIITD SmartPhone Fingerphoto Database v1 (ISPFDv1)

Considered Datasets

FVC2006

Subset	Type	Sensor	Color	Resolution	Instances / Samples
DB2-A	contact-based	optical	grayscale	400×560	140 / 1,680
DB3-A		thermal			
DB4-A	synthetic	–			

Figure: DB2-A

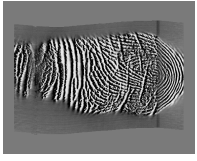


Figure: DB3-A

Figure: DB4-A

Considered Datasets

MCYT fingerprint subcorpus

Subset	Type	Sensor	Color	Resolution	Instances / Samples
dp	contact-based	optical	grayscale	256×400	3,300 / 39,600
pb		capacitive		300×300	

Figure: db

Figure: pb

Considered Datasets

PolyU CL2D to CB2D

Subset	Type	Sensor	Color	Resolution	Instances / Samples
CB-S1	contact-based	optical	grayscale	328×356	336 / 2,016
CB-S2					160 / 960
CL-S1	contactless	camera	RGB	1,400×900	336 / 2,016
CL-S2					160 / 960

Figure: CB-S1

Figure: CB-S2

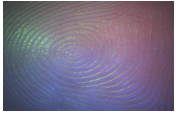


Figure: CL-S1

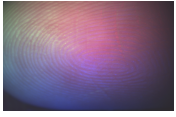


Figure: CL-S2

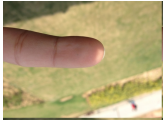
Considered Datasets

ISPFDv1

Subset	Type	Sensor	Color	Resolution	Instances / Samples
LS	contact-based	optical	grayscale	544×253	128 / 1,024
NI	contactless	iPhone 5	RGB	3,264×2,448	128 / 1,024
NO					
WI					
W0					

Figure: LS

Figure: NI



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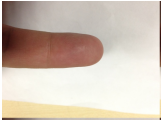

Figure: WI

Figure: WO

Preprocessing Pipeline

Preprocessing Pipeline executed on the contactless datasets

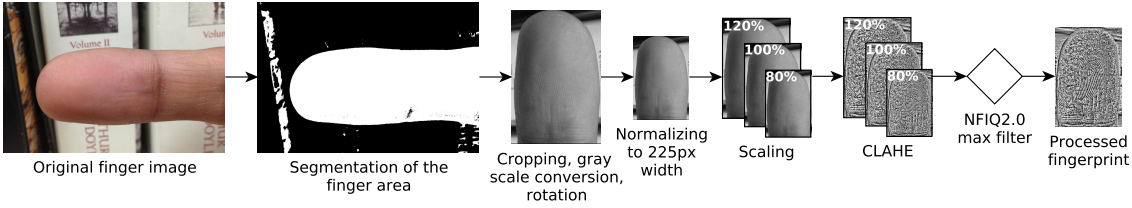

Figure: Proposed processing pipeline

- Segmentation and cropping is executed only on the ISPFDv1 dataset.

Processed Samples

Figure: Processed ISPFDv1 NI sample

Figure: Processed PolyU CL-S1 sample

Evaluation Method

Biometric Performance Prediction

- Probability distribution over NFIQ2.0 scores
- Error-versus-Reject Curves (ERCs)
  - Correlation between quality scores and comparison score
  - Sort samples by quality score (descending)
  - Consider the first one as reference and all other as probe
  - Start at a FNMR of 10%
  - Iteratively exclude a portion of samples and recompute FNMR
- Assumption: FNMR decreases if quality measure is a good predictor
  - Partial Area Under Curve (PAUC) indicates prediction performance

Results

FVC2006

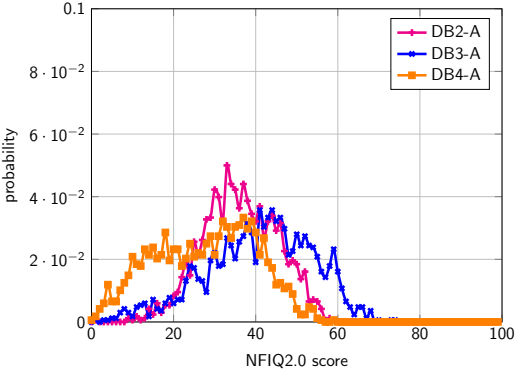

Figure: PDF FVC2006

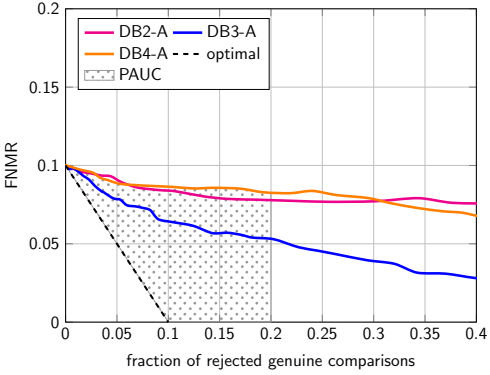

Figure: ERC FVC2006

Results

MCYT

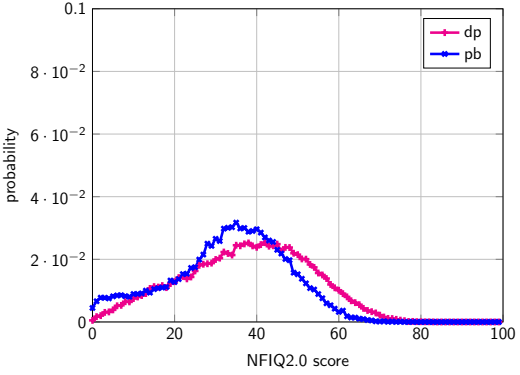

Figure: PDF MCYT

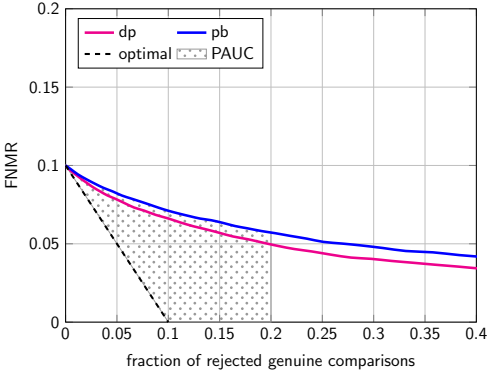

Figure: ERC MCYT

Results

PolyU

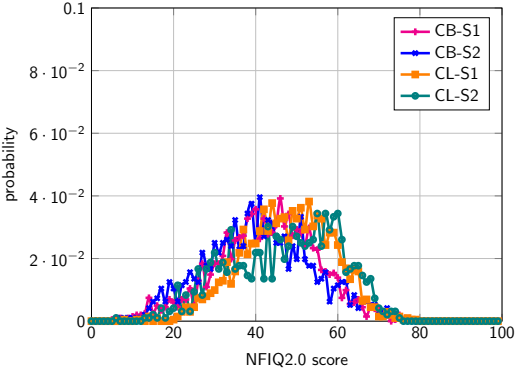

Figure: PDF PolyU

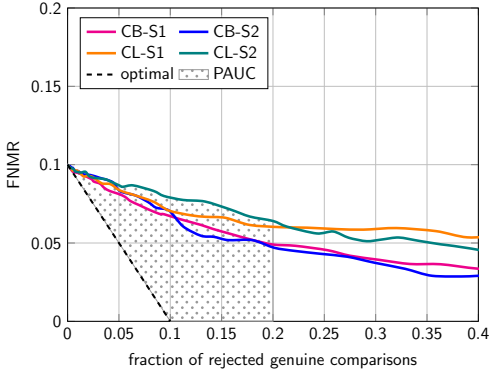

Figure: ERC PolyU

ISPFDv1

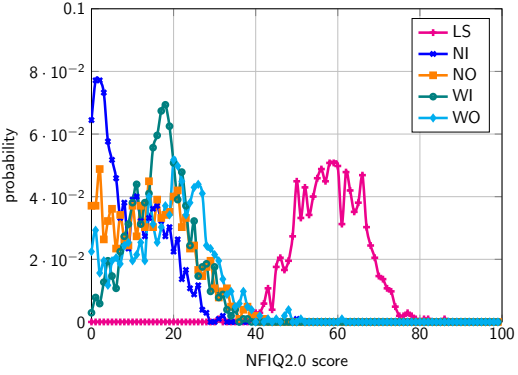

Figure: PDF ISPFDv1

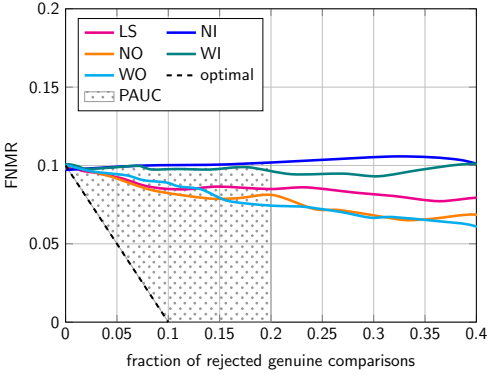

Figure: ERC ISPDFDv1

NFIQ2.0 Score distribution, EERs and ERCs

DB	Subset	Preproc.	Avg. NFIQ2.0 score	EER (%)	ERC AUC
FVC06	DB2-A	–	36.07 (±9.07)	0.15	0.01261
	DB3-A	–	40.92 (±12.85)	6.71	0.00883
	DB4-A	–	27.80 (±12.28)	2.90	0.01261
MCYT	dp	–	37.58 (±15.17)	0.48	0.00868
	pb	–	33.02 (±13.99)	1.35	0.00970
PolyU	CB-S1	–	42.64 (±11.96)	0.67	0.00890
	CB-S2	–	40.97 (±13.14)	1.75	0.00893
	CL-S1	proposed	47.71 (±10.86)	3.91	0.00998
	CL-S2	proposed	47.08 (±13.21)	3.17	0.01106
ISPFDv1	LS	–	58.19 (±7.70)	0,51	0.01275
	NI	proposed	9.62 (±7.65)	34.64	0.01205
	NO	proposed	14.70 (±9.39)	28.12	0.01214
	WI	proposed	16.86 (±7.02)	35.67	0.01465
	WO	proposed	18.60 (±9.77)	25.29	0.01246

Interpretation

Our Investigations show

- Predictive power is low on datasets of homogeneous quality
  - Especially if no significant performance gains can be expected
  - Cmp.: e.g. FVC2006 DB2-A, ISPFDv1
- Predictive power is high on datasets of heterogeneous quality
  - Cmp.: e.g. FVC06 DB3-A, MCYT dp or PolyU CL-S2
  - Under these conditions the predictive power of NFIQ2.0 is slightly worse on contactless samples

Further we conclude:

- NFIQ2.0 can be a useful quality assessment for contactless fingerprints
- Predictive power depends on the employed preprocessing

Analysis on a self-captured Database

Experiments on own Database

- Android app running on a smartphone
- Automatic capturing of the four inner-hand fingers
- On-device processing
- On-device NFIQ2.0 for integrated quality assessment
- Remote feature extraction and comparison

J. Priesnitz, et al. "Mobile Touchless Fingerprint Recognition: Implementation, Performance and Usability Aspects." arXiv preprint, 2021.

Analysis on a self-captured Database

Experimental Setup

Type	Setup	Device	Subjects	Rounds	Samples
Contactless	Box	Google Pixel 4	28	2	448
Contactless	Tripod	Huawei P20 Pro	28	2	448
Contact-based	–	Crossmatch Guardian 100	29	2	464

Figure: Contactless tripod

Figure: Contactless box

Figure: Contact-based setup

Analysis on a self-captured Database

Results

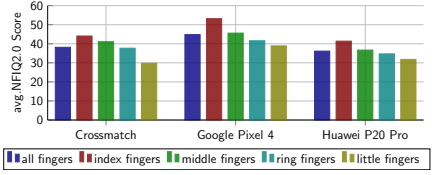

Figure: Averaged NFIQ2.0 scores obtained from the considered databases.

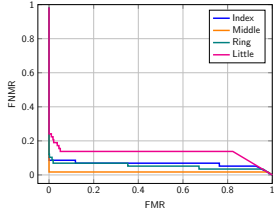

Figure: Contactless tripod setup

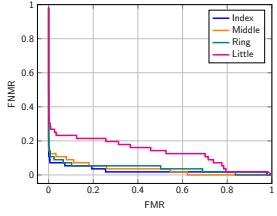

Figure: Contactless box setup

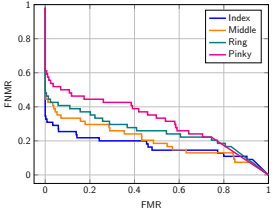

Figure: Contact-based

Analysis on a self-captured Database

Results

Capturing device	Fingers	Avg. NFIQ2.0 score	EER (%)
Contactless Box	index fingers	53.16 (± 11.27)	7.14
	middle fingers	45.59 (± 11.06)	8.91
	ring fingers	41.57 (± 12.89)	7.14
	little fingers	38.88 (± 14.21)	21.43
Contactless Tripod	index fingers	41.38 (± 14.29)	21.81
	middle fingers	36.68 (± 13.01)	28.58
	ring fingers	34.68 (± 14.28)	29.62
	little fingers	31.79 (± 14.63)	38.98
Contact-based	index fingers	44.06 (± 17.53)	8.62
	middle fingers	41.08 (± 19.71)	1.72
	ring fingers	37.68 (± 17.08)	6.90
	little fingers	29.78 (± 19.94)	13.79

Analysis on a self-captured Database

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Analysis on a self-captured Database

In our experimental setup...

- NFIQ2.0 scores drop from index finger to little finger
  - The drop is not reflected in the comparison scores
- Contactless samples of the same subject show comparable NFIQ2.0 scores but different comparison scores
  - Predictive power of NFIQ2.0 for unoptimized contactless samples is rather low
- Samples where not optimized for NFIQ2.0

Thank you for your attention!

Questions?

Publications related to this talk:

- *J. Priesnitz, et al. "Touchless Fingerprint Sample Quality: Prerequisites for the Applicability of NFIQ2.0" BIOSIG, 2020.*
- *J. Priesnitz, et al. "Mobile Touchless Fingerprint Recognition: Implementation, Performance and Usability Aspects." arXiv preprint, 2021.*