







Evaluation of Quality Features for NFIQ 2.0

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IBPC 2012 / Satellite Workshop on NFIQ 2.0
NIST Gaithersburg, March 5, 2012
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Considered Features (1)

- **NFIQ1** quality features
 - Foreground (FG)
 - Number of minutiae (NoMin)
 - Minutiae (minimum) quality count (min05, min06, min075, min08, min09)
 - Quality zone (blockwise) count (QZ1, QZ2, QZ3, QZ4)
- Features derived from digitalPersona **FingerJetFX** software
 - Minutiae Count (MinCount) → cut-off at 65
 - Minutiae quality (interval) count (MinQual4 – MinQual10)
 - Average minutiae quality (AvMinQual)

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Considered Features (2)

- Quality features from ISO/IEC 29794-4, implemented by **hda** (Olsen)
 - Frequency Domain Analysis (FDA)
 - Local Clarity Score (LCS)
 - Orientation Certainty Level (OCL)
 - Orientation Flow (OF)
 - (Radial) Power Spectrum (PS)
 - Ridge Valley Uniformity (RVU)

Considered Features (3)

- Additional quality features implemented **hda** Olsen
 - Gabor
 - Gabor Segment (GS)
 - Gabor Shen (GSh)
 - Mu
 - Mu Mu Block (MMB)
 - Mu Mu Sigma Block (MMSB)
 - Mu Sigma Block (MSB)
 - Sigma
 - Sigma Sigma Block (SSB)

Objectives of Evaluation

- Determine set of features eligible for training of NFIQ2 algorithm
 - Relevance
 - How indicative is the feature for biometric performance of fingerprints
 - Independence:
 - Is the metric redundant with other features?
 - May be good or bad

Evaluation Methods

- Spearman (rank) correlation
 - With utility computed from comparison scores acc. ISO 29794-1
 - Utility used as ground truth
 - With other features
- Measure Impact on biometric performance
 - ROC curve approach: Error rate determination for quality control
 - Error reject curves (ERC): impact of quality filtering to FNMR

Data Basis for Evaluation

- FingerQS Database
 - Collected in BSI project
 - 79056 fingerprints from 1098 volunteers
 - 8 fingers per individual
 - 9 live scans per finger
 - Taken with 3 different optical sensors
- Similarity Scores computed with 3 SDKs
 - 8 genuine scores and 60 impostor scores per fingerprint
 - Utility values computed from scores according to ISO/IEC 29794-1

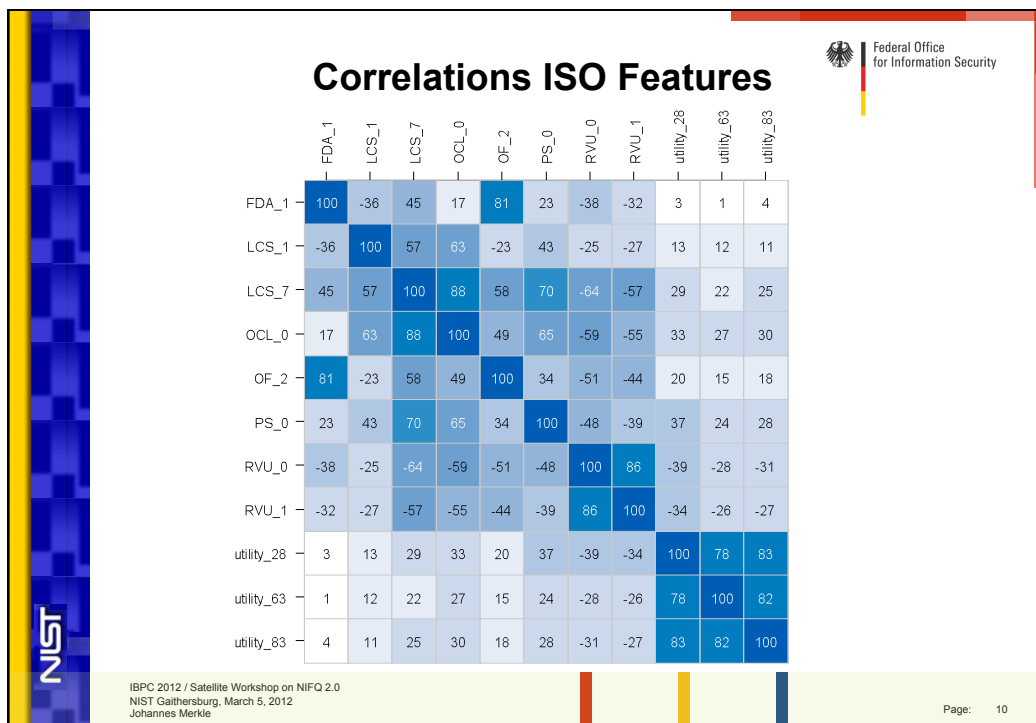
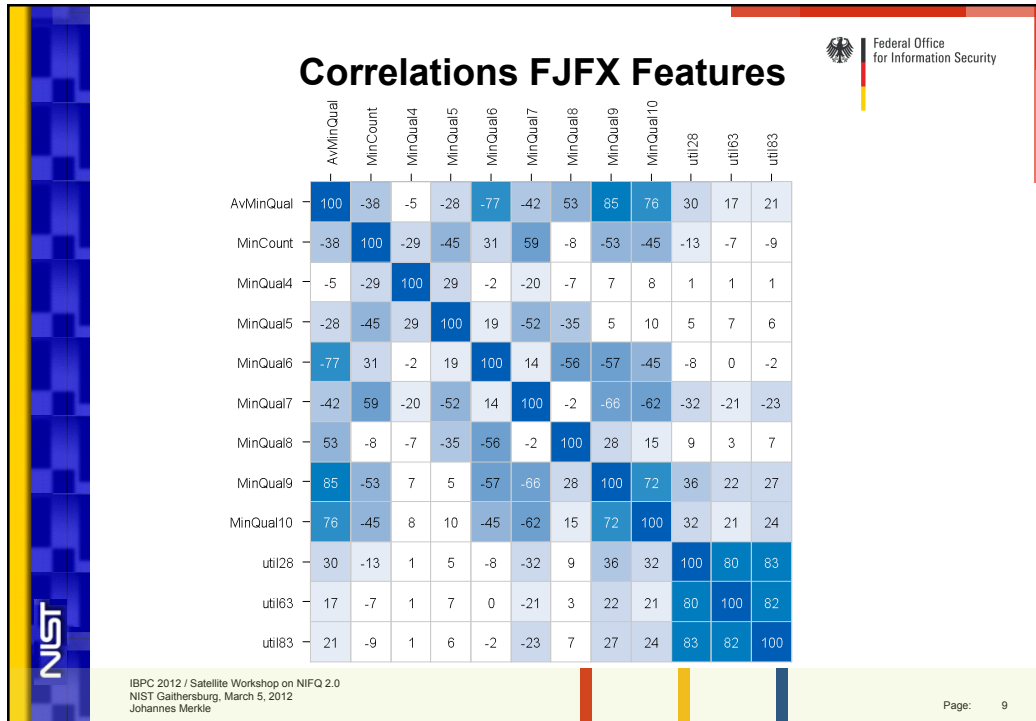
$$o(x) = \frac{\mu(G(x)) - \mu(I(x))}{\sigma(G(x)) + \sigma(I(x))}$$

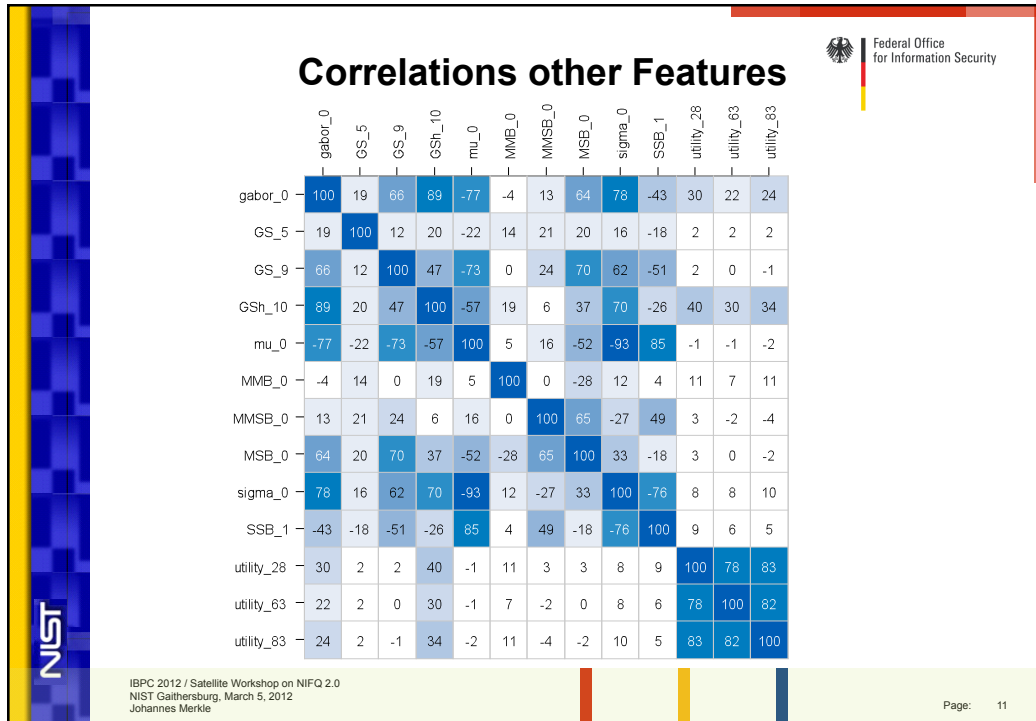
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Correlations NFIQ1 Features

	foreground	NoMinutiae	min05	min06	min075	min08	min09	QualZone1	QualZone2	QualZone3	QualZone4	util28	util63	util83
foreground	100	46	47	47	42	34	26	-19	-43	-4	25	16	2	9
NoMinutiae	46	100	49	49	50	46	35	20	18	24	-24	-7	-7	-6
min05	47	49	100	99	93	76	54	-46	-47	-47	58	33	21	26
min06	47	49	99	100	95	79	56	-45	-47	-48	58	33	21	26
min075	42	50	93	95	100	90	69	-36	-42	-45	52	31	21	26
min08	34	46	76	79	90	100	87	-25	-32	-37	41	28	19	24
min09	26	35	54	56	69	87	100	-20	-20	-31	31	23	16	20
QualZone1	-19	20	-46	-45	-36	-25	-20	100	52	66	-85	-34	-22	-27
QualZone2	-43	18	-47	-47	-42	-32	-20	52	100	39	-75	-31	-18	-25
QualZone3	-4	24	-47	-48	-45	-37	-31	66	39	100	-86	-40	-27	-31
QualZone4	25	-24	58	58	52	41	31	-85	-75	-86	100	44	29	35
util28	16	-7	33	33	31	28	23	-34	-31	-40	44	100	80	83
util63	2	-7	21	21	21	19	16	-22	-18	-27	29	80	100	82
util83	9	-6	26	26	26	24	20	-27	-25	-31	35	83	82	100

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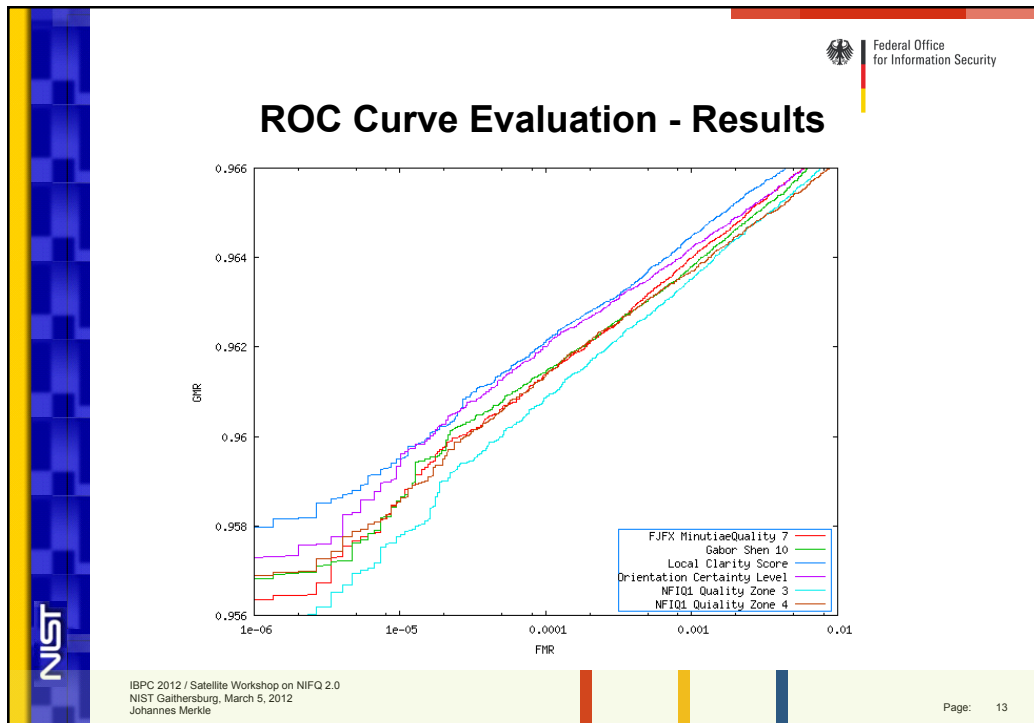



ROC Curve Evaluation -Method

- Simulate biometric application using feature for quality control
 - Select best of 3 impressions during enrolment
 - Realistic scenario: used in enrolment for German visa
 - Compute ROC curve from comparison scores of selected fingerprints
 - No quality control for probe fingerprint

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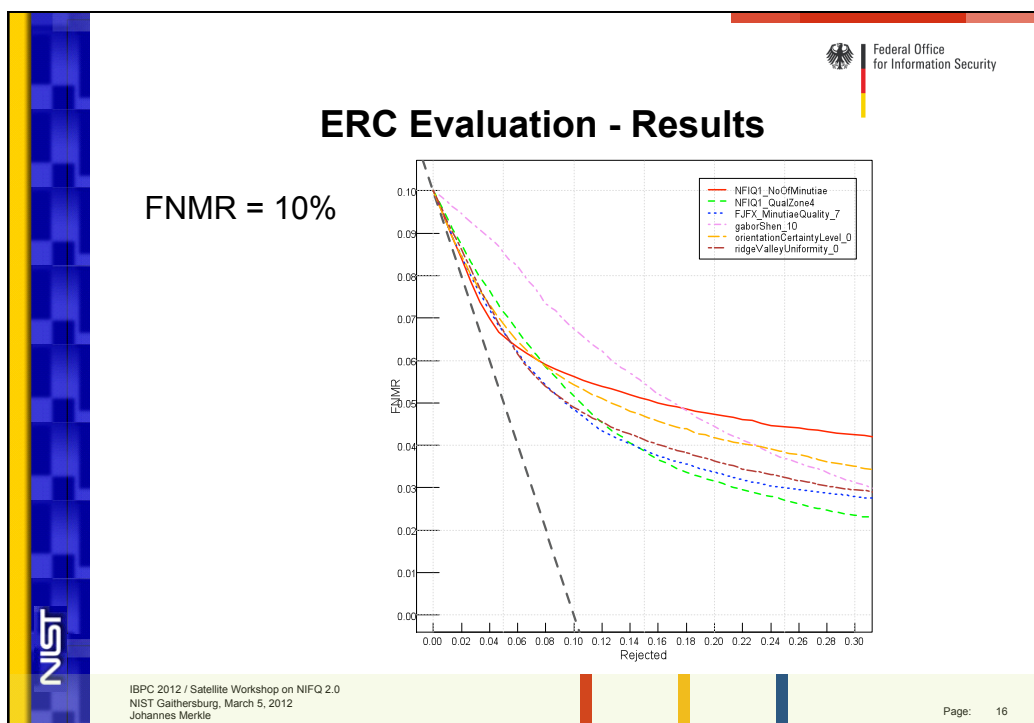
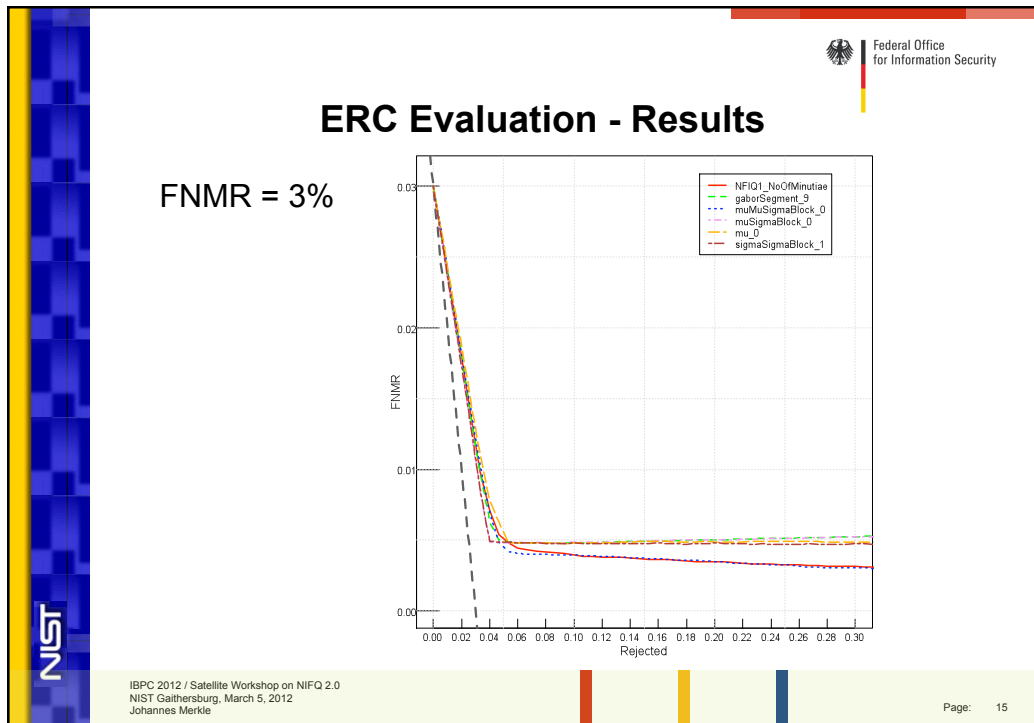
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ERC Evaluation -Method

- Determine impact of quality filtering on FNMR
 - Feature values used as quality indicator
- Fix operational threshold at certain FNMR
 - Filter genuine comparisons with respect to feature value
 - Neglect scores where value of reference or probe fingerprint is too low
 - Show dependency of FNMR on feature threshold
- We used FNMR = 3% and FNMR = 10%
- Can show non-monoton dependency of performance on feature values

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Summary of Results

Correlation	ROC (SDK 28)	ROC (SDK 63, 83)	ERC FNMR = 3%	ERC FNMR = 10%
NFIQ1 QZ4	LCS1	LCS1	MMSB	NFIQ1 QZ4
GSh	LCS7	LCS7	NFIQ NoMin	FJFX MinQual7
NFIQ1 QZ3	OCL	OCL	GS9	RVU0
RVU0	GSh	GSh	Mu	OCL
OCL	FJFX MinQual7	NFIQ1 QZ4	MSB	NFIQ1 NoMin
PS	NFIQ1 QZ4	RVU0	SSB	GSh
RVU1	NFIQ1 QZ3	OF	FJFX MinQual7	RVU1
FJFX MinQual9	MMSB	PS	RVU0	NFIQ1 QZ2
NFIQ1 QZ1	NFIQ1 NoMin	FJFX MinQual7	OCL	NFIQ1 QZ3
NFIQ1 Min05/06	RVU0	MMB	NFIQ1 QZ3	FJFX MinQual9
NFIQ1 Min07	MMB	MMSB	OF	OF
FJFX MinQual7	OF	NFIQ1 QZ3	NFIQ1 QZ4	SSB
FJFXMinQual10	PS	NFIQ1 NoMin	NFIQ1 FG	LCS7

Additional Evaluation

- 3 databases with different sensor technologies
- Comparison scores from other SDK

CASIA	Utility	FVC2002Db3	Utility	FVC2004Db3	Utility
GSh	0,24	PS	0,13	PS	0,54
PS	0,23	Gabor	0,12	Gabor	0,51
OCL	0,22	RVU	0,11	FDA	0,44
OF	0,22	OF	0,07	LCS	0,41
Gabor	0,22	FDA	0,07	OCL	0,40
FDA	0,20	OCL	0,04	GSh	0,36
LCS	0,17	GSh	0,03	RVU	0,24
RVU	0,13	LCS	0,01	OF	0,24

Optical

Capacitive

Thermal sweeping

Features to be considered for NFIQ2.0

- From NFIQ1
 - Quality Zone 3 and 4
 - Foreground
 - But: No minutiae-based features (computation too slow)
- From ISO/IEC TR 29794-4
 - Frequency Domain Analysis
 - Local Clarity Score
 - Orientation Certainty Level
 - Orientation Flow
 - Power Spectrum
 - Ridge Valley Uniformity
- New features
 - Gabor
 - Gabor Segment
 - Gabor Shen
 - Mu Mu Sigma Block
 - Mu Sigma Block
- From digitalPersona FingerJetFX
 - E.g. Number of Minutiae (remove cut-off)
 - E.g. Minutiae quality counts



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