Utility Validation of a New Fingerprint Quality Metric

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Outline

Motivations

Quality of biometric data is essential :

- Optimizing the enrolment process (reference with the best quality),
- Additional information for multi-biometrics,
- Use as soft biometric information ...

Open questions

Which measure to qualify the quality of a biometric data ?
How to validate a quality metric ?

Quality metrics

Many contributions :
Bolle et al. 1999, Shen et al. 2001, Lim et al. 2002, Tabassi et al. 2004 (NFIQ), Lee et al. 2005, Olsen et al. 2012, Li et al. 2013, El Abed et al. 2013 (Q)...

Validation approaches

Contributions :

- Fernandez et al. 2007 : relation between the assessment values and the matching performance ;
- Grother and Tabassi 2007 : rank-ordered detection error trade-off (DET) and Kolmogorov Smirnov (KS) statistic ;
- Zhao et al. 2010 : correlation with the OCL and STD metrics.

$\Longrightarrow$ NFIQ 2.0 definition

Continuous quality metric

Combination of different features with a GA (El Abed et al. 2013) :

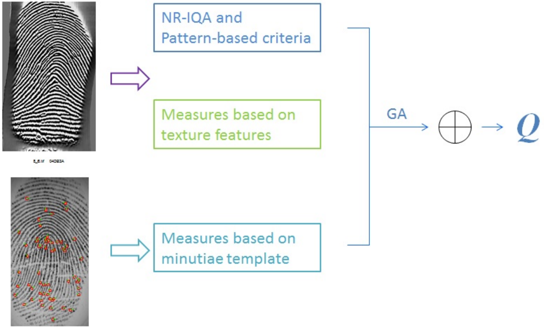
$$Q = \frac{1}{A}\sum_{i=1}^{N} \alpha_i C_i \ , \qquad (1)$$

where
N is the number of quality features C_i $(i = 1, \ldots, N)$,
α_i are linear coefficients,
A is a normalization constant.

α_i are obtained by optimizing a fitness function defined by an utility rule i.e. Pearson correlation between quality metric and genuine matching score (GMS).

Quality Features from Image and Minutiae Templates

- No-Reference Image Quality Assessment and pattern-based features ;
- Texture features, e.g. LBP, Gabor, etc ;
- Minutiae features, e.g. DFT of 3 elements of minutia point.



Databases

TABLE 1: Details on the three FVC databases.

DB	Sensor Type	Resolution	Image Dim	DB Size
2002DB2A	Optical	500dpi	296×560	100×8
2004DB1A	Optical	500dpi	480×640	100×8
2004DB3A	Thermal Sweeping	512dpi	300×480	100×8

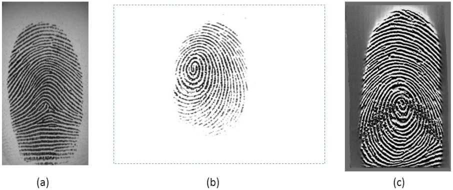


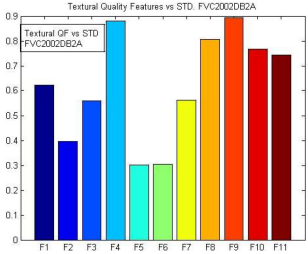
FIGURE 1: Samples of the three databases

Protocol

- Minutiae templates are extracted by using MINDTCT.
  A Template is consisted of minutia points,
  $m_i = \{x,\ y,\ \theta,\ q\}$,
  where (x, y) is the location of minutia point,
  θ is the orientation of the minutia point,
  q is the quality value of minutiae m_i.
- Matching scores are computed by using Bozorth3 ;
- NFIQ values of fingerprints (NBIS).

Correlation analysis

- Correlation between features and STD or OCL
- Correlation between genuine matching scores and a quality metric



	FVC2002DB3A	FVC2004DB1A	FVC2004DB3A
NFIQ	-0.269	-0.207	-0.246
Q	0.460	0.316	0.535

TABLE 2: Correlation analysis between genuine matching scores and quality metrics

Quality distribution (Chen et al. 2005)

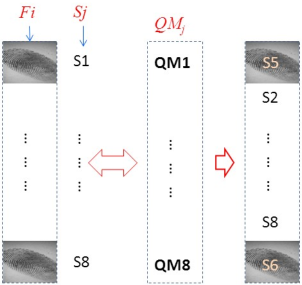
- Sort all fingerprint samples in an ascending order of their quality ;
- Divide sorted samples into 5 bins ;
- Calculate Equal Error Rate (EER) for each bin.

EER values should be monotonically increasing (quality), e.g.
$EER_i = \{20\%,\ 17\%,\ \cdots,\ 8.92\%\},\ i = (1, 2, \cdots, 5).$

Bin No.	B1	B2	B3	B4	B5
Q (FVC2004DB1)	22.2%	16.6%	17.2%	17.8%	13.3%
NFIQ (FVC2004DB1)	15.8%	18.1%	17.7%	23.2%	26.5%
Q (FVC2004DB3)	14.2%	8.9%	7.4%	5.8%	4.2%
NFIQ (FVC2004DB3)	7.5%	8.1%	13.4%	12.9%	29.8%

Best Quality Sample as Reference (1/5)

Select the best quality sample as reference with three strategies :



F_i : i^{th} finger ;
S_j : j^{th} sample of i^{th} finger ;
QM_j : corresponding quality value of S_j.
$EER(S_j)$: EER value when choosing S_j as reference template.

- $E^i_{worst} = max(EER(S_1), EER(S_2), \cdots, EER(S_8))$ (worst)
- $E^i_{NFIQ} = min(NFIQ_1, NFIQ_2, \cdots, NFIQ_8)$;
- $E^i_{Q} = max(Q_1, Q_2, \cdots, Q_8)$.
- $E^i_{best} = min(EER(S_1), EER(S_2), \cdots, EER(S_8))$ (best)

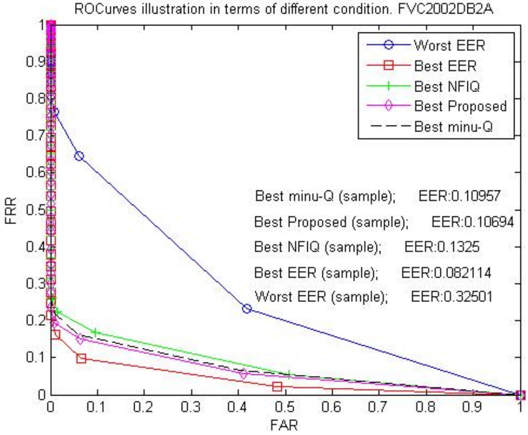


FIGURE 2: ROC curve computed by choosing the reference with different quality metrics for FVC2002DB2A

Best Quality Sample as Reference (3/5)

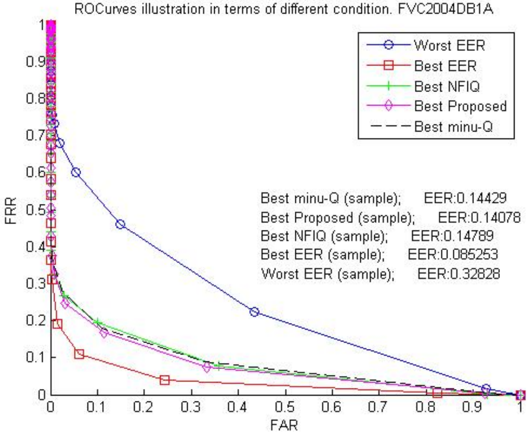


FIGURE 3: ROC curve computed by choosing the reference with different quality metrics for FVC2004DB1A

Best Quality Sample as Reference (4/5)

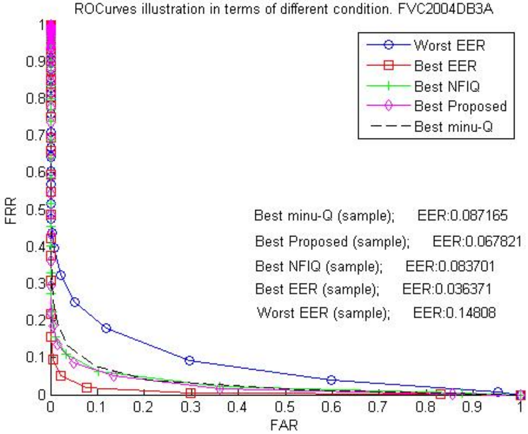


FIGURE 4: ROC curve computed by choosing the reference with different quality metrics for FVC2004DB3A

R_{AUC} criterion

$$R_{auc} = \frac{Q_{auc} - B_{auc}}{W_{auc} - B_{auc}}, \quad (2)$$

Where

Q_{auc} is the AUC value with a quality metric for defining the reference.

B_{auc} and W_{auc} are AUC values correspond to the best and worst strategies.

	FVC2002DB2A	FVC2004DB1A	FVC2004DB3A
Q	0.898	0.809	0.771
NFIQ	0.830	0.774	0.721

TABLE 3: R_{AUC} criterion for each quality metric.

Conclusions

- Utility validation method of a quality metric ;
- Comparison with other methods (similar assessment) ;
- Validation method could be used for NFIQ 2.0.

Perspectives

- Improve the quality metric ;
- Quality assessment on fingerprint ISO templates.

Thanks for Your Attention

http://www.epaymentbiometrics.ensicaen.fr/