Automatic Enhancement of Interoperability between Optical Fingerprint Sensors

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Summary

- WVU Multi-Sensor Fingerprint Collection
- Fingerprint Interoperability Assessment
- The Proposed Enhancement Approach
- Results

Multi-Sensor Fingerprint Collection

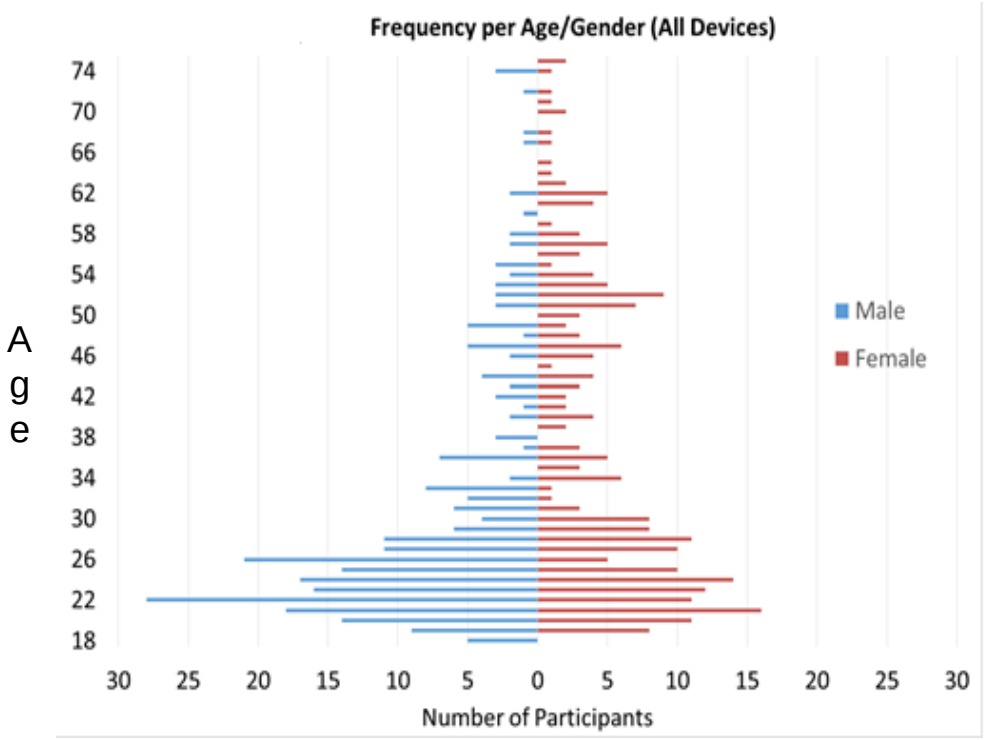
- Data collection performed at West Virginia University
- FBI Certified livescan fingerprint sensors
- Number of participants: 500
- Rolled individual fingerprints on right and left hands; left, right and thumb slaps per session
  - In the analysis we use right point finger only.
- Two sequential sessions for each sensor
- Inked rolled prints

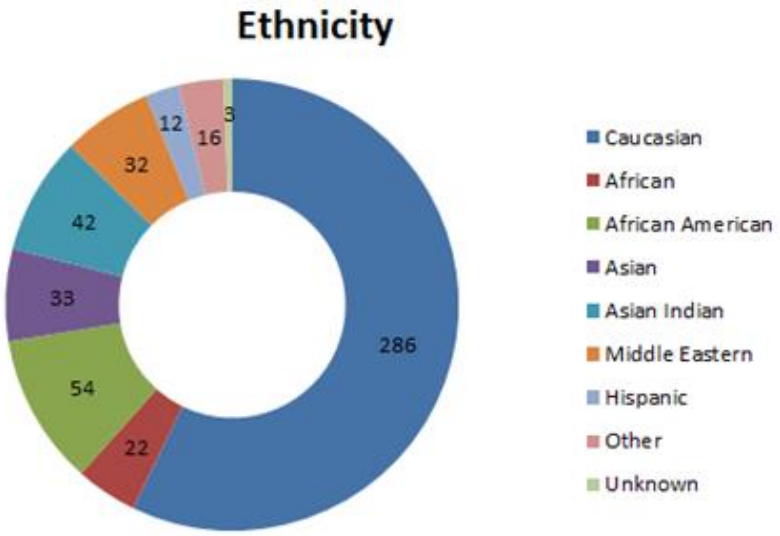
Optical Fingerprint Sensors

	Device	Model	Resolution (dpi)	Image Size (pixels)	Capture Area (mm)
D0	Cross Match	Guardian R2	500	800 x 750	81 x 76
D1	i3	digID Mini	500	752 x 750	81 x 76
D2	L1 Identity Solutions	TouchPrint 5300	500	800 x 750	81 x 76
D3	Cross Match	Seek II	500	800 x 750	40.6 x 38.1

Collection Demographics

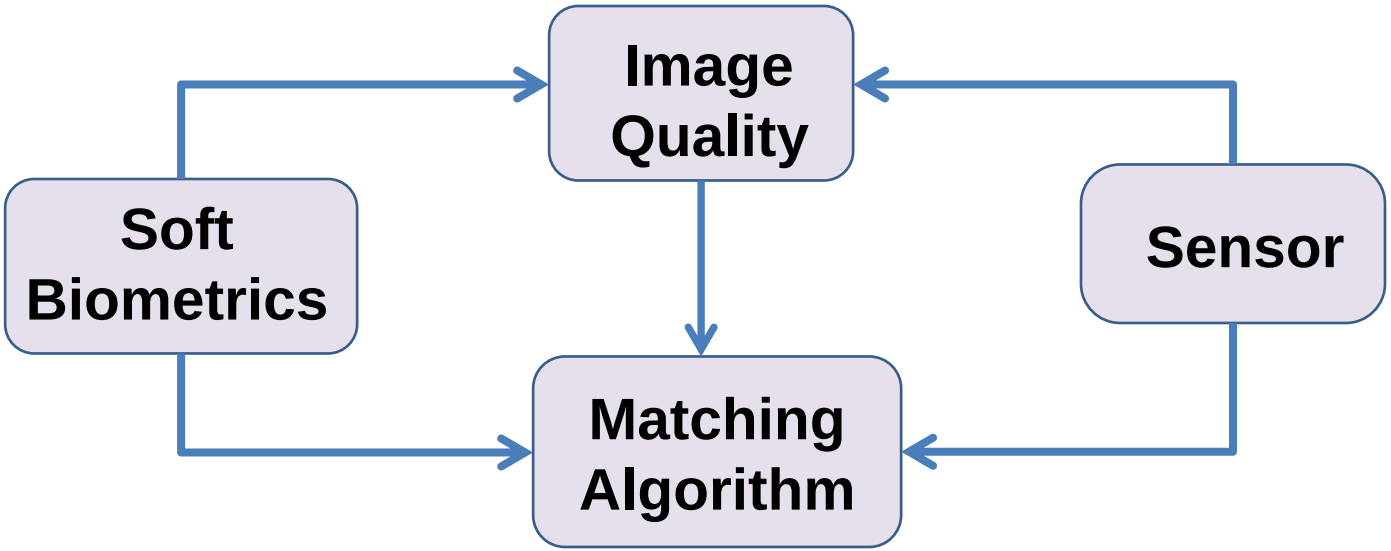
- Provided Ethnicity, Age, Gender, Weight, Height





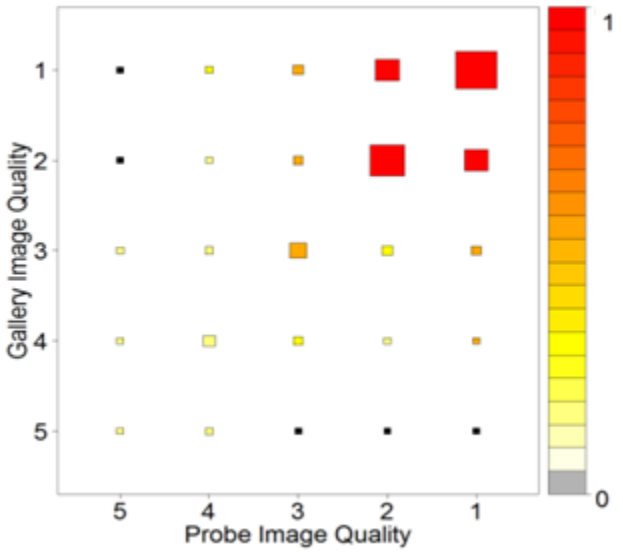
L. Lugini, E. Marasco, B. Cukic, I. Gashi, "**Interoperability in Fingerprint Recognition: a Large Scale Study**", the 43rd Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN 2013), pp. 1-6, 24 - 27 June 2013, Budapest, Hungary.

Diversity in Fingerprint Images



- Optical Sensors
- Image Quality: NFIQ
- Soft-Biometrics: Age / Gender

Diversity from Image Quality



- Average normalized match score vs. NFIQ image quality for all the considered devices
- The size of the square indicates the frequency

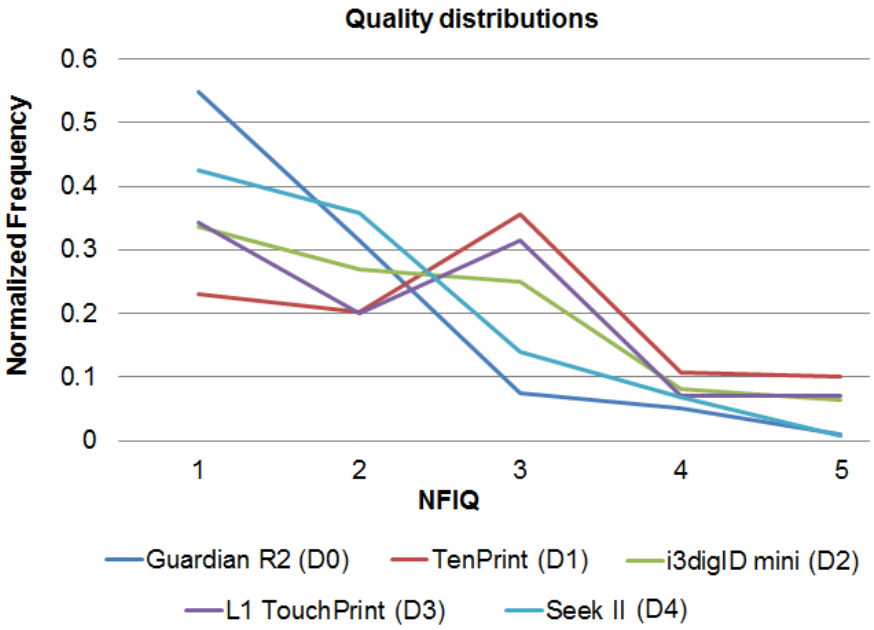
Participant		Device			
Age	Gender	D0	D1	D2	D3
18-29	Male	1.530	1.878	1.905	1.702
	Female	1.396	1.935	2.104	1.735
30-59	Male	1.526	2.500	2.513	1.712
	Female	1.748	2.684	2.820	2.112
60+	Male	2.500	3.222	3.278	2.778
	Female	3.071	3.476	3.524	3.095

- Device Ranking by Image Quality
- Average NFIQ image quality measures

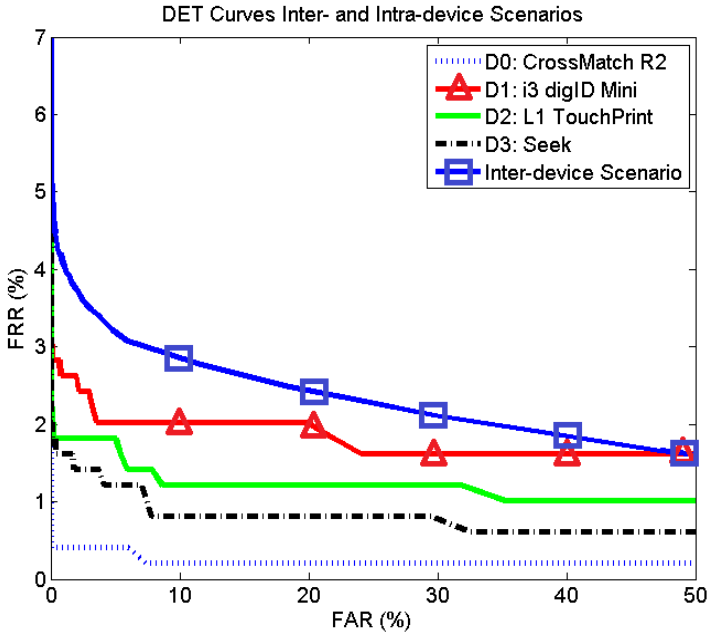
- Stephen Mason, Ilir Gashi, Emanuela Marasco, Luca Lugini, Bojan Cukic, "**Deployment Strategies for Diverse Fingerprint Biometric Systems**", IEEE/IFIP International Conference on Dependable Systems and Networks (DSN), June 23 - 26, 2014, Atlanta, Georgia (USA).

Sensor Diversity

- Impact of Sensors on Image Quality

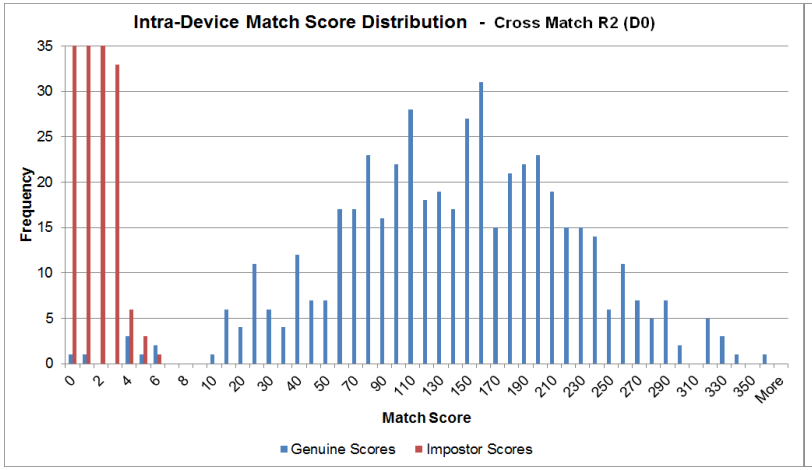


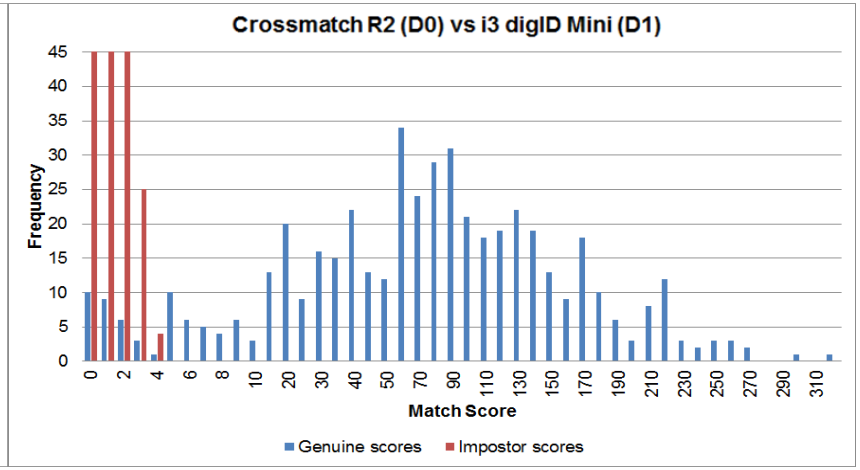
- Impact of Sensors on Matching Algorithm



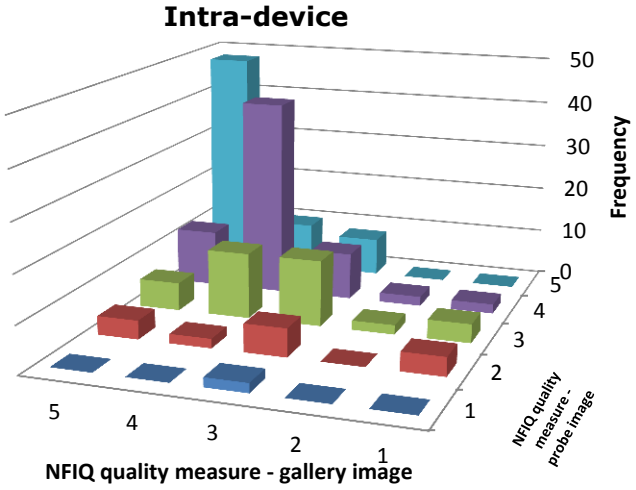
Sensor Diversity

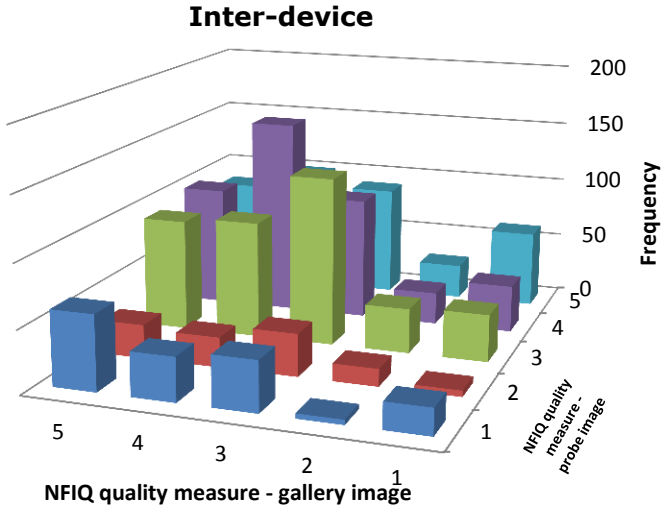
- Impact of Device Diversity on Matching





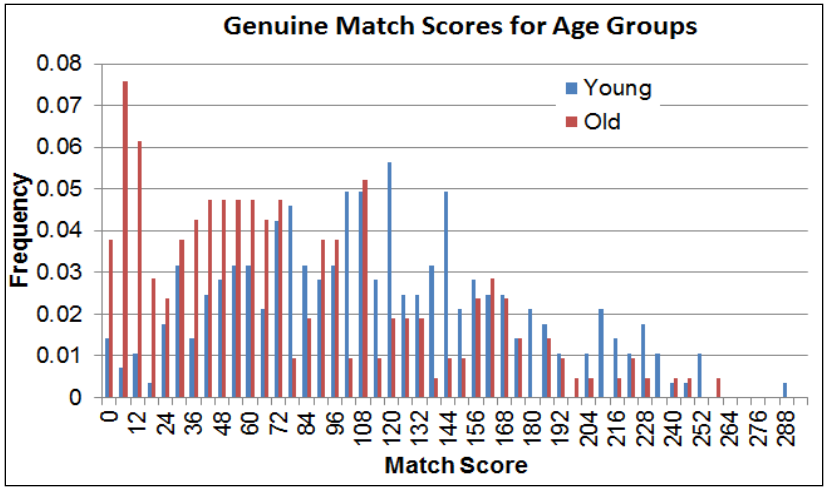
- Impact of Device Diversity and Image Quality on Matching

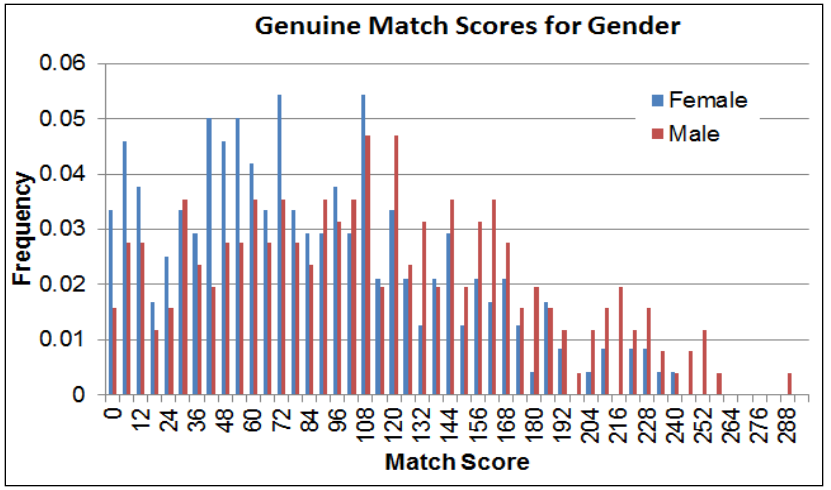




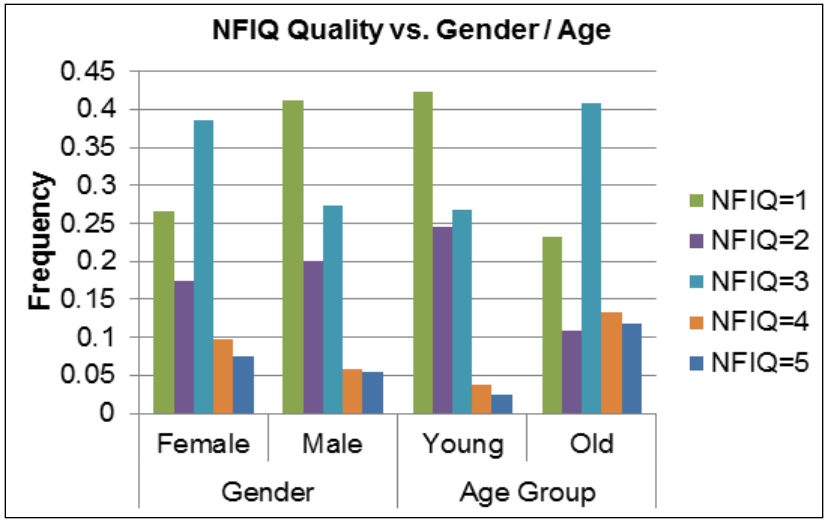
Diversity from Soft Biometrics

- Impact of Age / Gender on Matching Algorithms





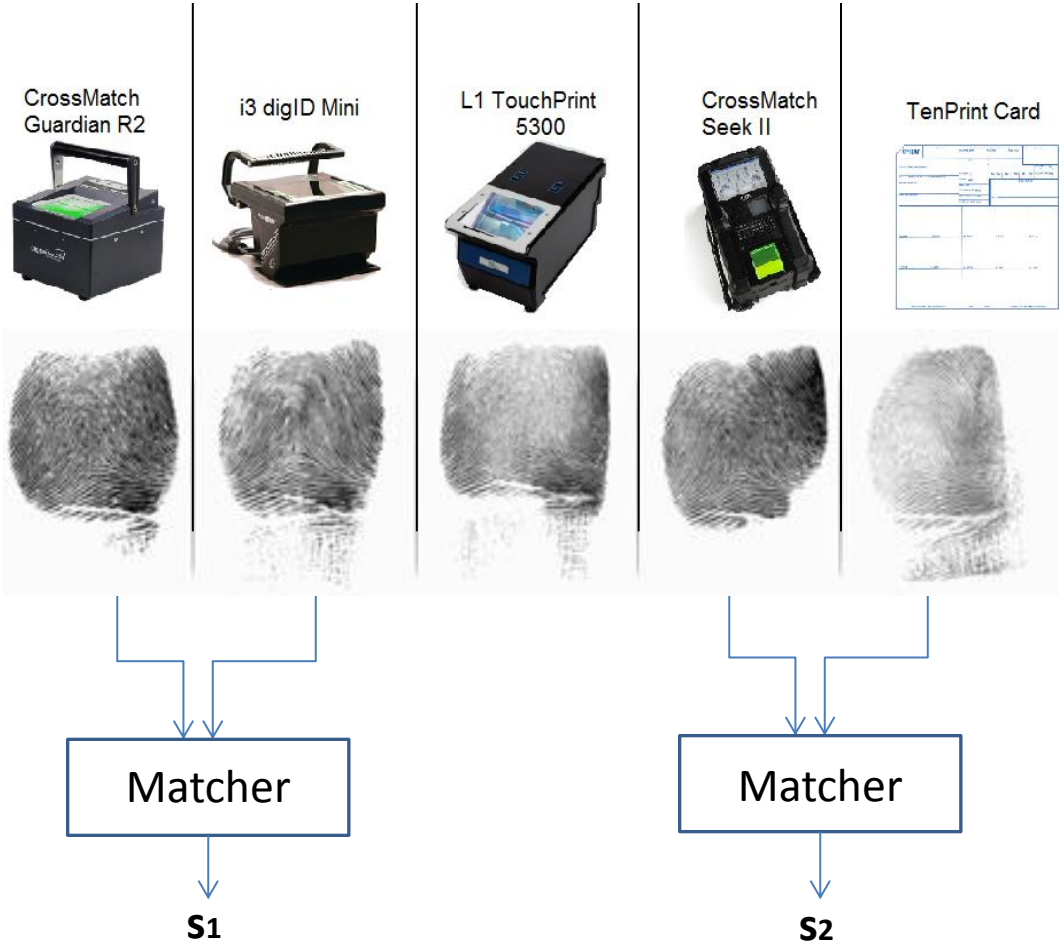
- Impact of Age / Gender on Image Quality



- Age Groups
  - Young: 18-29
  - Elderly: 30-75
- TouchPrint 5300 device

One Identity Multiple Biometric Sources

- Can we achieve error rates in cross-device matching as good as within same-device?



- Higher intra-device genuine match scores indicate interoperability problems

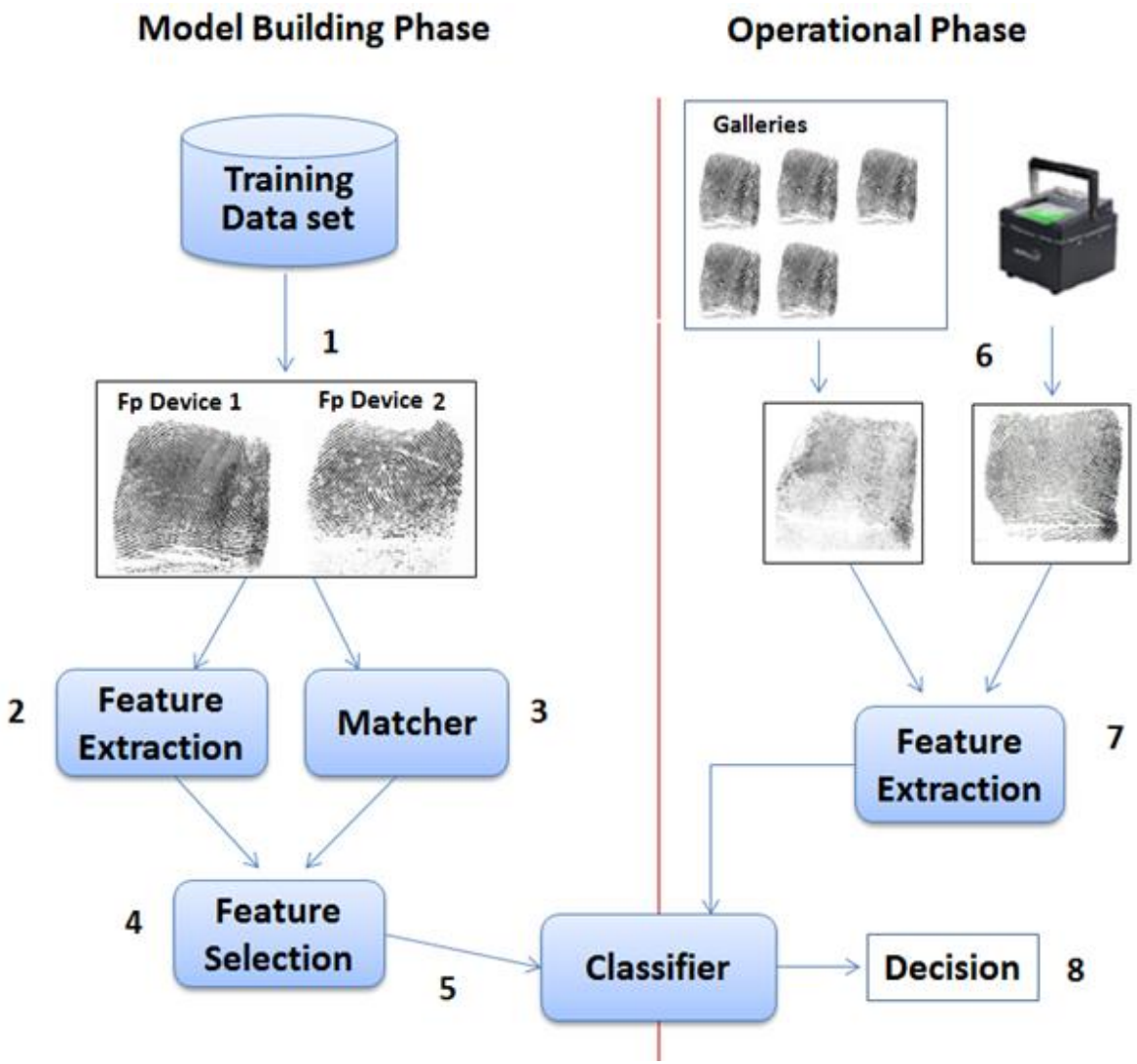
Related Works

1. Image Quality (local gradients) for score calibration [1]
   - Biosecure DS2 database, 207 subjects
   - Thermal vs. Optical
   - Results: TER is reduced from 15.834% to 15.150% (at EER)
   - Weakness: association of each device with a quality cluster

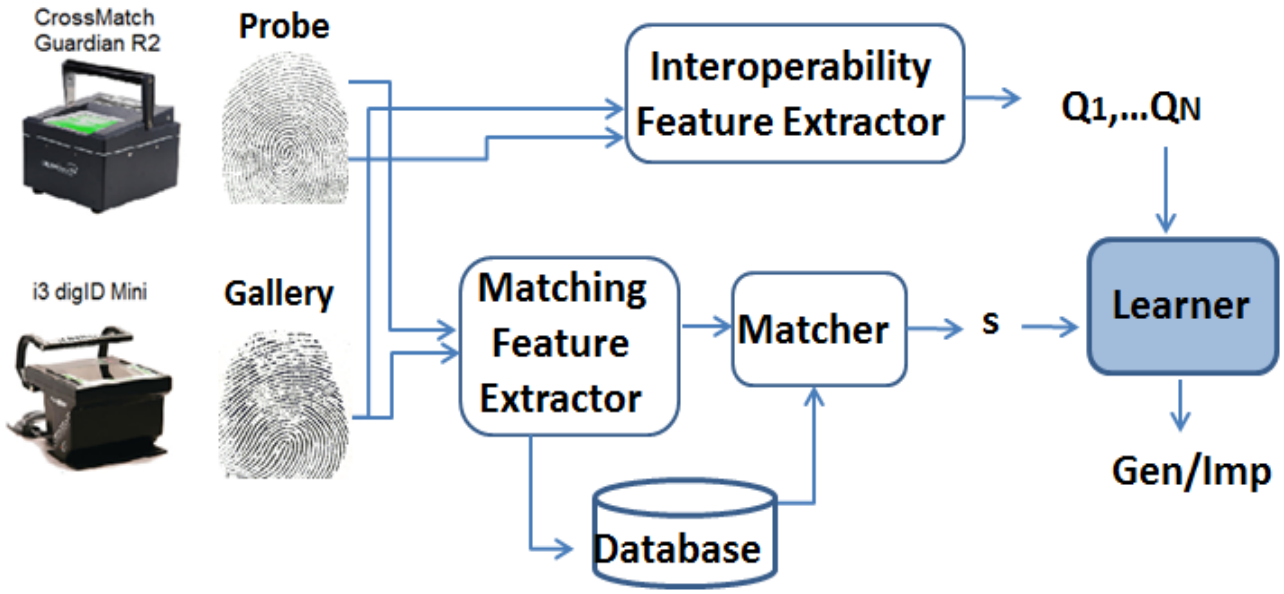
2. Distortion compensation model [2]
   - Optical vs. Capacitive
   - WVU data set of 71 subjects, MSU data set of 128 subjects
   - Results: at FAR= 0.01% GAR from 35% to 75% (Verifinger)
   - Weakness: non-linear transformation of minutiae points, old sensors

[1] Poh, N., Kittler, J.; Bourlai, T., "Quality-Based Score Normalization With Device Qualitative Information for Multimodal Biometric Fusion," *IEEE Trans. on SMC*, 2010
[2] Ross, A., and Nadgir R., "A thin-plate spline calibration model for fingerprint sensor interoperability", *IEEE Transactions on KDE* , 2008

The Proposed Approach



The Proposed Approach

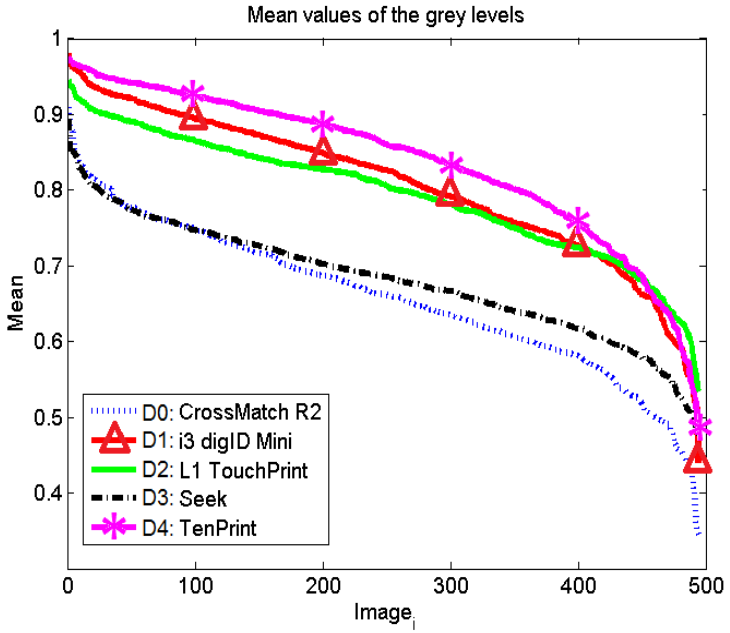


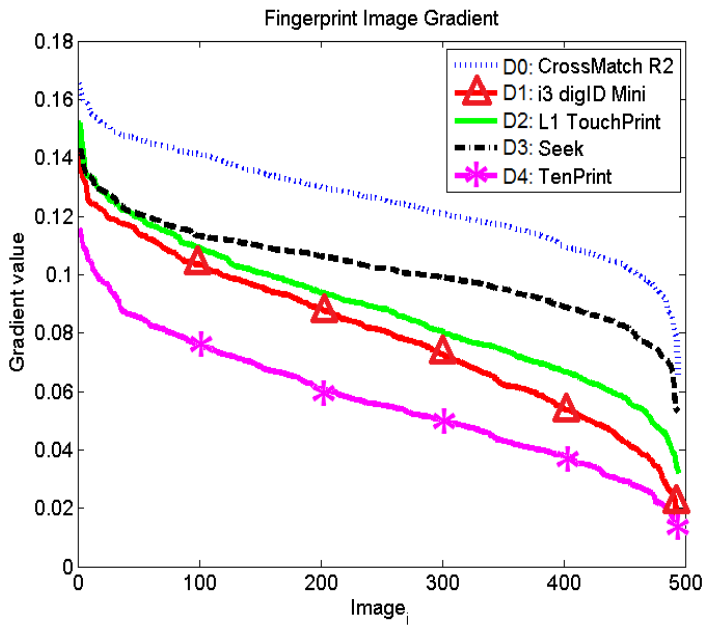
- Compensation after matching
- Modeling qualitative information of the device and how it relates to match score
- The set of interoperability features is concatenated with the match score

- E. Marasco, L. Lugini, B. Cukic, T. Bourlai, "**Minimizing the impact of Low Interoperability between Optical Sensors**", IEEE Sixth International Conference on Biometrics: Theory, Applications and Systems (BTAS) 2013, pp. 1-8, Washington D.C. (USA).

Sample Interoperability Features

- Image quality (NFIQ and MITRE)
- Minutiae count
- Pattern noise
- Intensity-based statistics
- Alignment

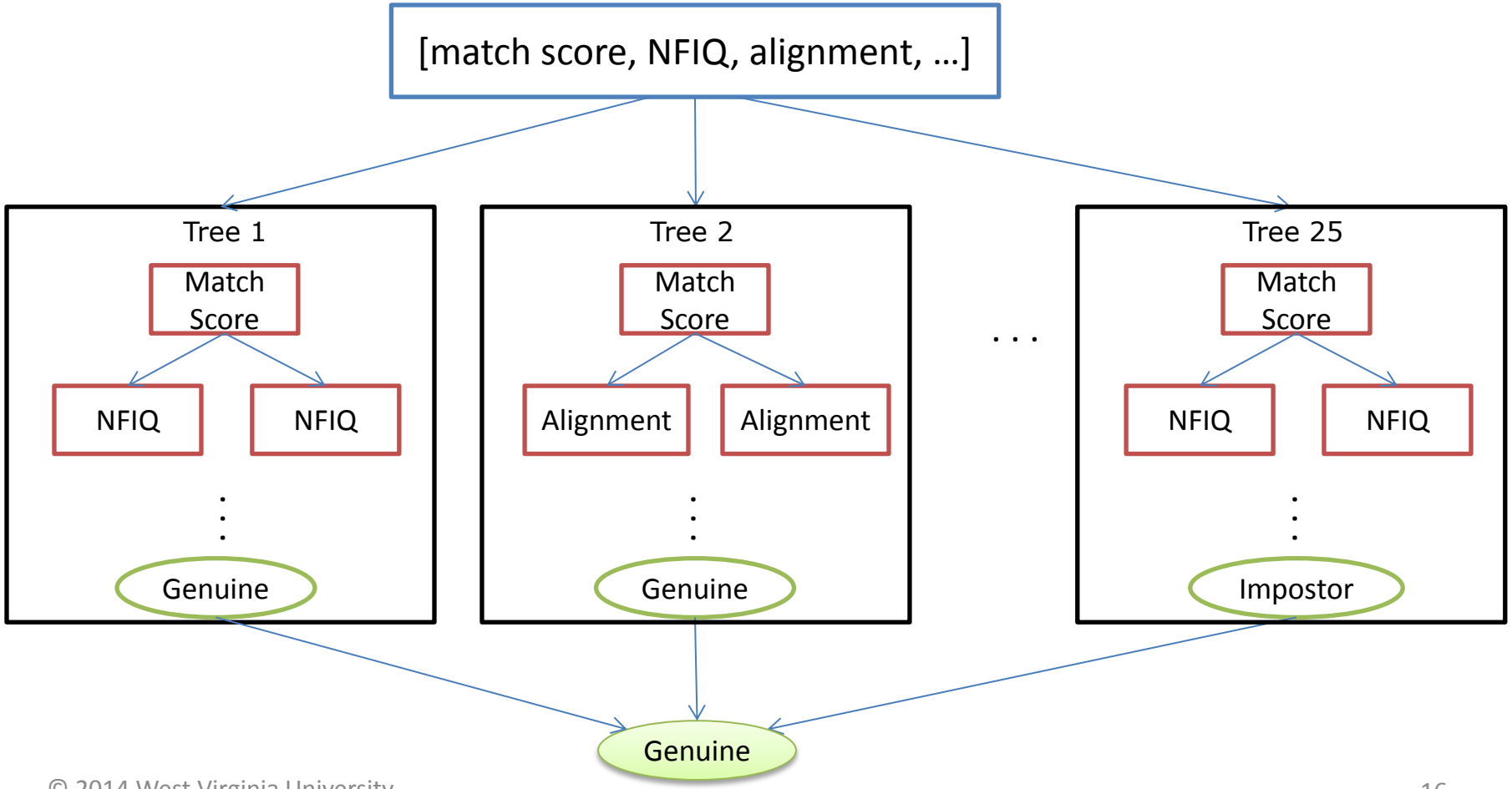




Invention disclosure

Classification

- Random Forest-based classification
- 10-Fold Cross Validation (25% training)



Results

- Using a preliminary set of features

Learner	Training	FMR	FNMR
Random Forest	10-Fold CV 10 Trees	0.006%	3.279%
	25% 10-Fold CV (25 Trees)	0.005%	3.741%

Baseline	
FMR	**FNMR**
0.005%	6.696%
1.982%	3.741%

- Error rates of commercial fingerprint matchers increase when images are acquired using different devices
- Compensation after matching achieves a significant improvement of cross-device accuracy

Thanks for your attention!

Any Questions?

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