

NIST Studies of Biometric Fusion

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Overview

- The studies had two key goals:
 1. Evaluation of score-level fusion techniques:
 - Surveyed, selected and implemented eight techniques, and compared performance
 2. Used the most effective technique to measure benefits of fusion on a large face and multi-fingerprint dataset:
 - multi-instance (N-finger)
 - multi-modal (N-finger+face)
 - multi-matcher
 - multi-sample (multiple enrollments)

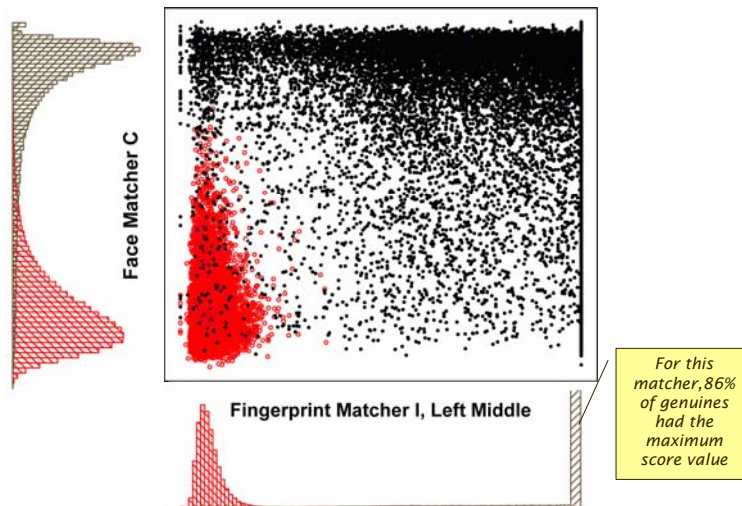
Data

- Operationally collected criminal arrest data from more than 187,000 individuals:
 - Face + segmented slap fingerprints for all ten fingers
 - 122k imposters
 - ~65k genuines
- Matchers from NIST SDK evaluations:
 - Fingerprint H, I, Q
 - Face A, B, C



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Score-Level Fusion



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Methods Implemented

- Surveyed a variety of score-level fusion methods, and selected these for implementation:
 - Neyman-Pearson (Likelihood) based methods
 - Product of likelihood ratios
 - Logistic regression
 - Linear methods
 - "Best" linear
 - Sum of z-normalized scores
 - Sum of raw scores
 - FAR-based methods
 - Product of FARs
 - Maximum and Minimum of FAR

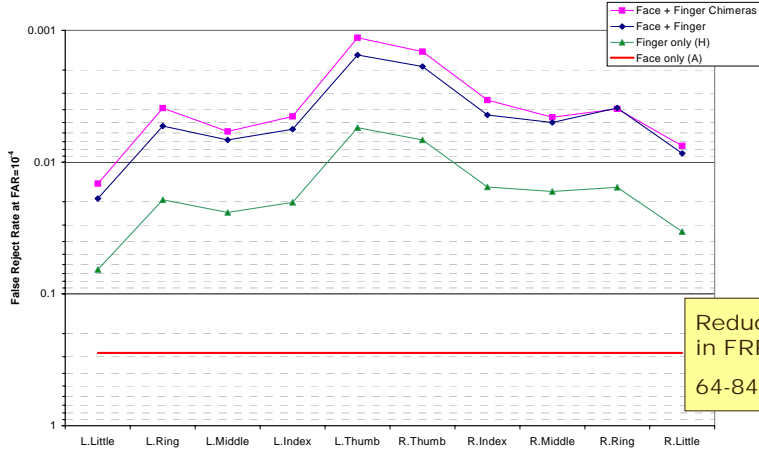
Evaluation of techniques: Findings

- **Product of Likelihood Ratios** was the most sophisticated and most accurate method implemented. This technique requires careful modeling of the score distributions.
 - Used in all subsequent charts
- **Logistic Regression** is highly effective, and relies on standard statistical tools.
- **Product of FARs** is most appropriate when no information on mate distribution is available; careful modeling of the non-mate distribution is required.
- **Best Linear** is conceptually simple, but requires joint sample (training) data. Implementation is relatively easy for 2-way fusion.
- **Simple Sum** of raw or z-normalized scores is effective for combining multiple instances or samples from one matcher.

Multi-modal fusion



Effect of Face and Single-Finger Fusion



Reduction in FRR:
64-84%

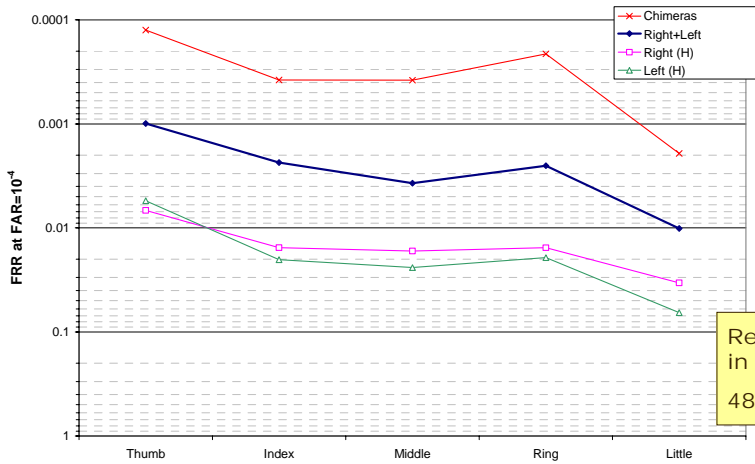


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Multi-instance fusion



Effect of Fusing Corresponding Fingers from Right and Left Hands



Reduction in FRR:
48-90%

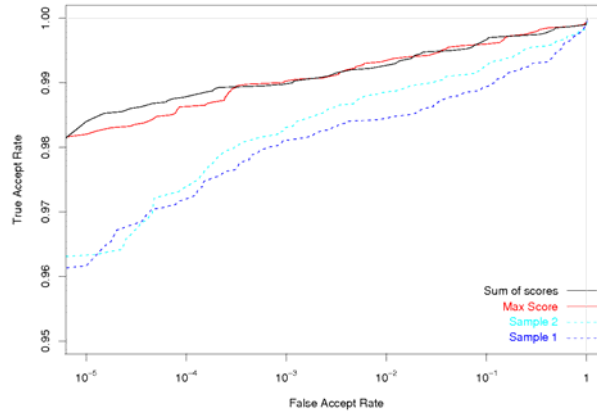


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Multi-sample fusion



Two Sample Fusion: Left Middle (Matcher I)

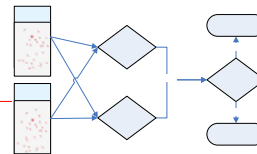


Reduction in FRR:
45-72%



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Multi-matcher fusion



	Face (n=3)	Fingerprint (n=10)		
		H+I	H+Q	I+Q
Min	10%	14%	8%	9%
Median	10%	25%	20%	20%
Max	13%	33%	32%	32%

Reduction in FRR where FAR = 10^{-4} , relative to the stronger of the inputs.

Reduction in FRR:
8-33%



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For details, please see the report + 5 appendices:

- B. Ulery, A. Hicklin, C. Watson, W. Fellner, P. Hallinan; "**Studies of Biometric Fusion**"; NIST Interagency Report 7346; September 2006.
- Appendices:
 - A: Terminology, Experimental Design and Data Description
 - B: Effectiveness of Score-Level Fusion
 - C: Evaluation of Selected Biometric Fusion Techniques
 - D: Fusion by Logistic Regression
 - E: Modeling Biometric Score Distributions
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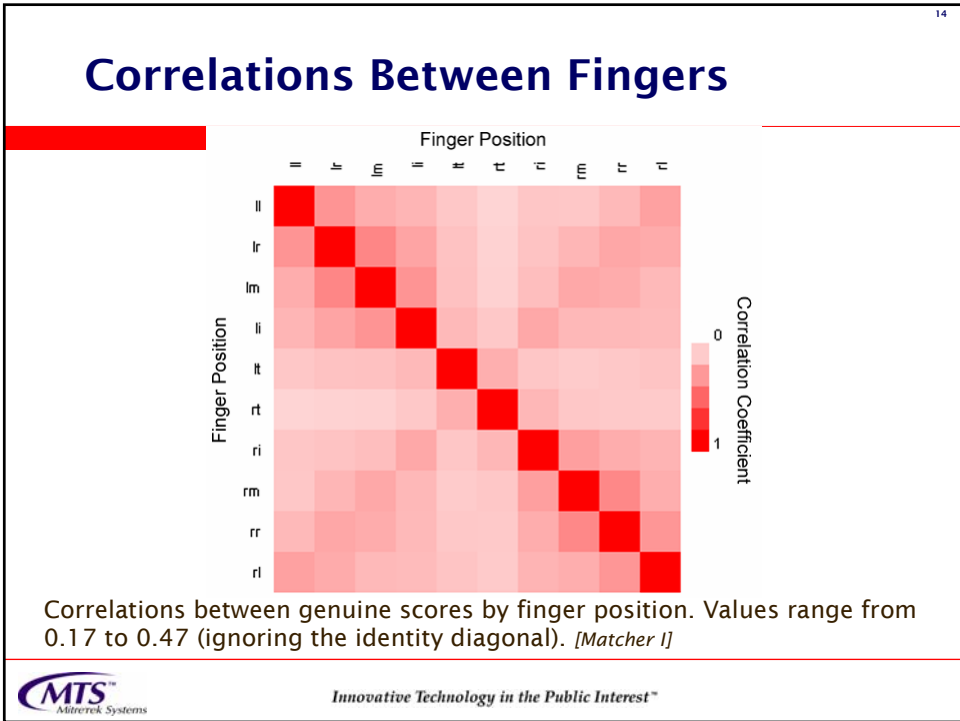
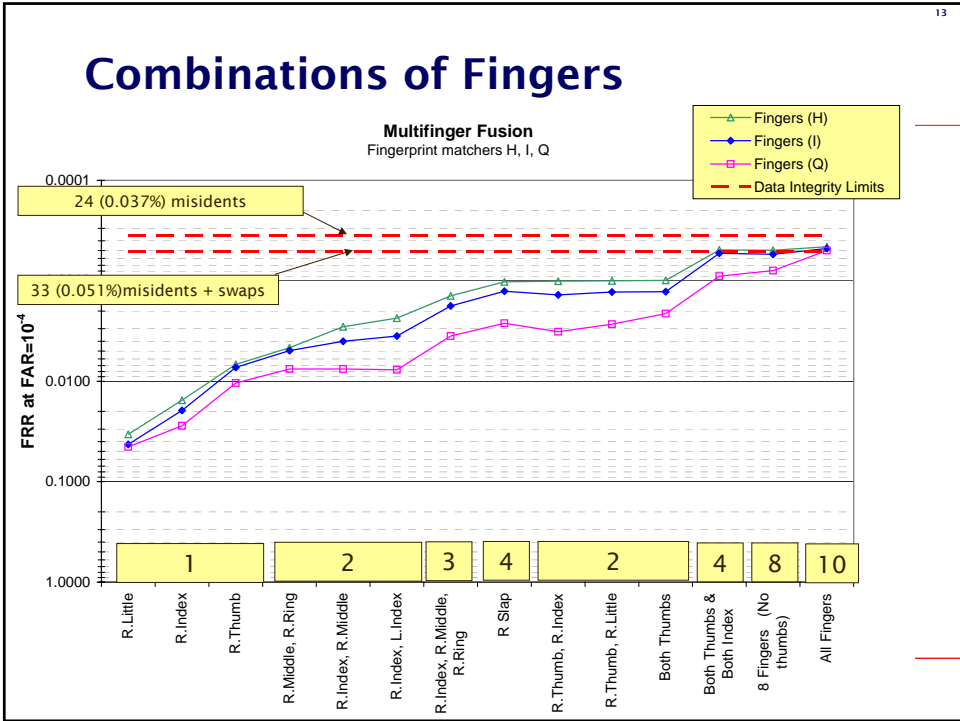
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General Observations

- Whether the benefits of fusion can be realized in practice depends on
 1. Availability of multi-biometric data and/or multiple matchers
 2. The accuracy of the matchers
 3. The correlation of the scores
 4. Representativeness and quantity of training data
 5. What is known about the data
 - *Detailed understanding of score distributions, the meaning of inherent score characteristics*
 6. How fusion is implemented
 - *the choice of fusion technique, details of its implementation, and its role in the system architecture*



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Combinations of Fingers + Face

