

3x2 Fingerprint Challenge

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MITRE Sponsored Research

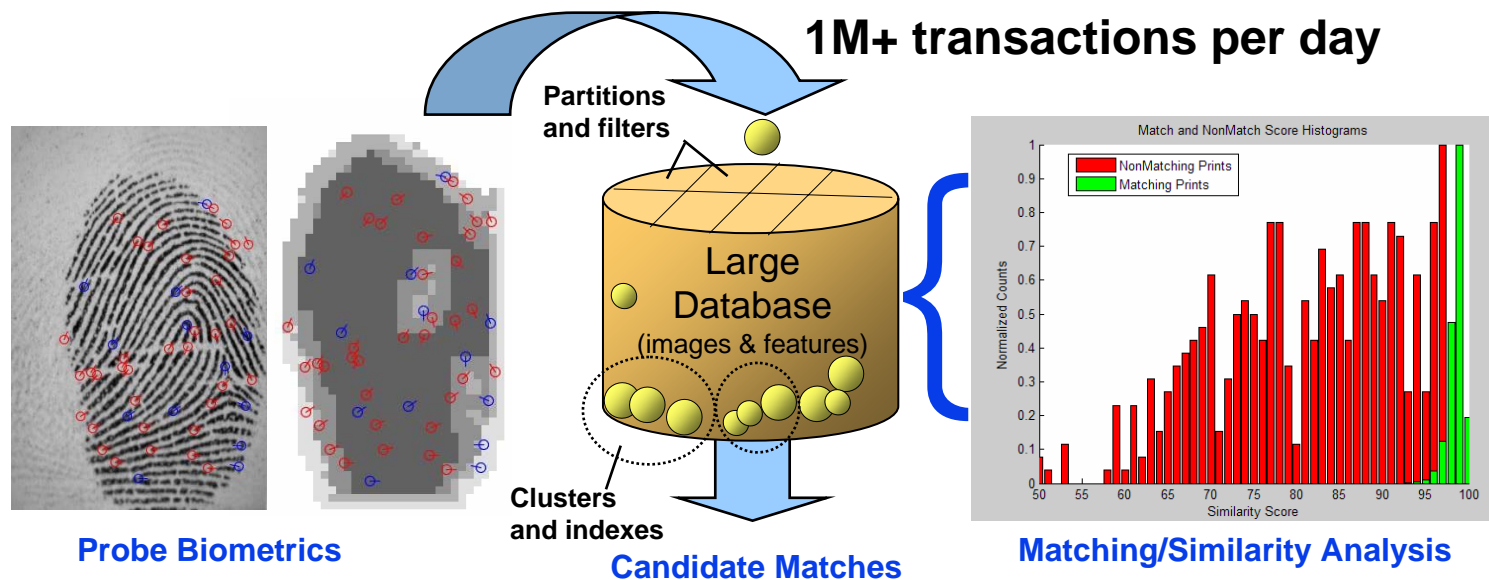


Problem

- **DHS, DoD, and other government agencies require comprehensive biometrics-based identification**
- **Collection and uses of biometrics are increasing**
 - DHS move to 10-print, automated face/iris being considered
 - DoD working with multi-biometric, multi-purpose collections and use
 - Next Generation DoJ IAFIS expected to include palm and possibly other data types
- **Identification performances degrades as size of database repository increases**
- **Identification processing is computationally complex, expensive, and based on closed software architectures**
- **Large scale fingerprint matching systems cost too much and work too slowly for upcoming needs**

Background

- **Biometric identification needs are increasing for travel, employment, entitlements, and security**
 - ~500 million border crossings per year, must prevent delays
 - **Mandate: 10-print enrollment, 1:1 verification (air/sea, to start)**
 - **Mandate: 1:few searches in less than 10 seconds, interoperate with IAFIS**
 - **Open set identification; not all encounters and ID checks can assume prior “enrollment”**



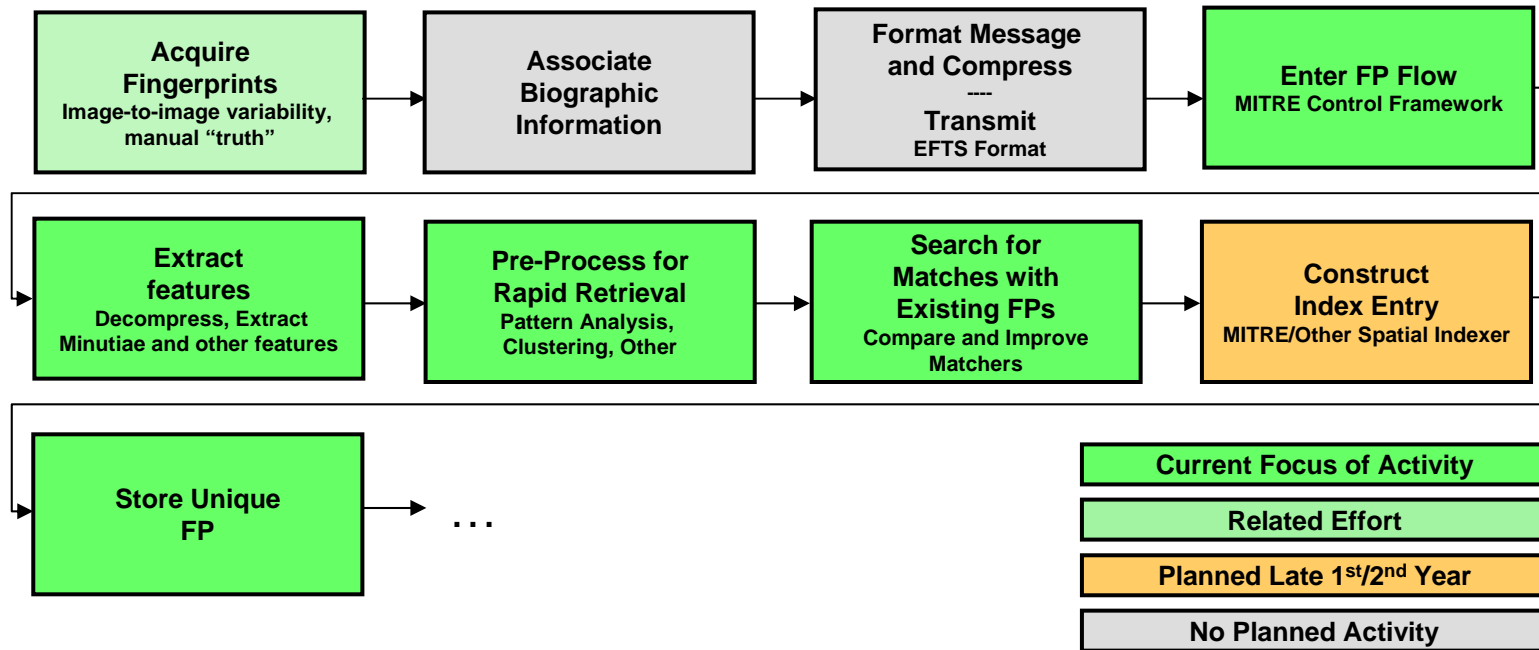
Objectives

- **Decrease the cost of fingerprint matching by 3 orders of magnitude (1/1000 the current cost of ~\$1.5M per “matcher”)**
- **Increase the speed of matching by 2 orders of magnitude (100x or 250M effective matches/second)**
- **Demonstrate open architecture solutions using commercially available platforms for computation, storage, and retrieval**

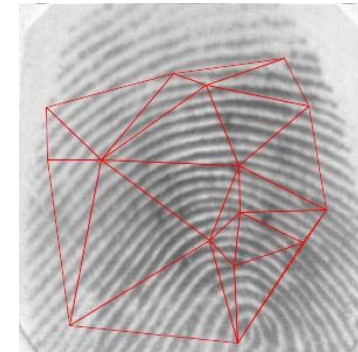
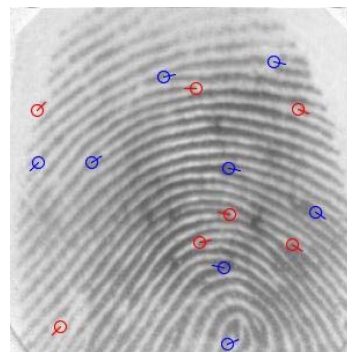
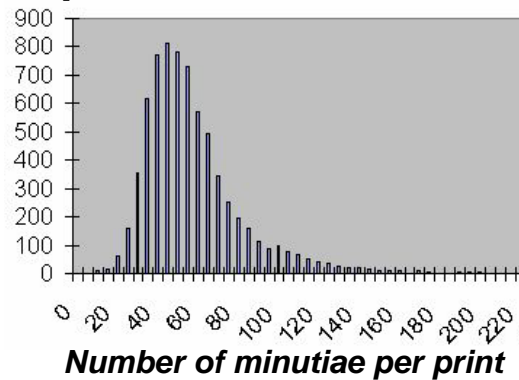
Activities

- **Verify Feasibility**
 - Establish performance metrics and computation/costs models
 - Assess effective alternatives based on high-performance computing approaches
- **Experimentation and Proof-of-Concept Engineering**
 - **Software**
 - Analyze and improve reference minutiae-based matcher
 - Develop/adopt advanced FP indexing method
 - **Hardware**
 - Evaluate data flow and control in cluster architecture
 - Evaluate critical functions on Cell Broadband Engine processors
 - Evaluate image analysis algorithms on graphics processing units
 - **Database Scalability**
 - Determine clustering properties for prints based on various features
 - Manually analyze, verify sample FP images to get “ground truth” (minutiae)
 - Assess repeatability/distortions of “slap” FP images over time

Highlight



Expected Minutiae Counts



Preliminary element-based matching

Highlight

“As is” software analysis for potential Cell BE computation

For each pair of minutia points ($\{x_k, y_k, t_k\}$ and $\{x_j, y_j, t_j\}$)

Store in sorted table an entry $\{d_{kj}, \beta_1, \beta_2, k, j, \theta_{kj}\}$ where

$$\Delta x = (x_j - x_k)$$

$$\Delta y = (y_j - y_k)$$

$$d_{kj} = \sqrt{\Delta x^2 + \Delta y^2}$$

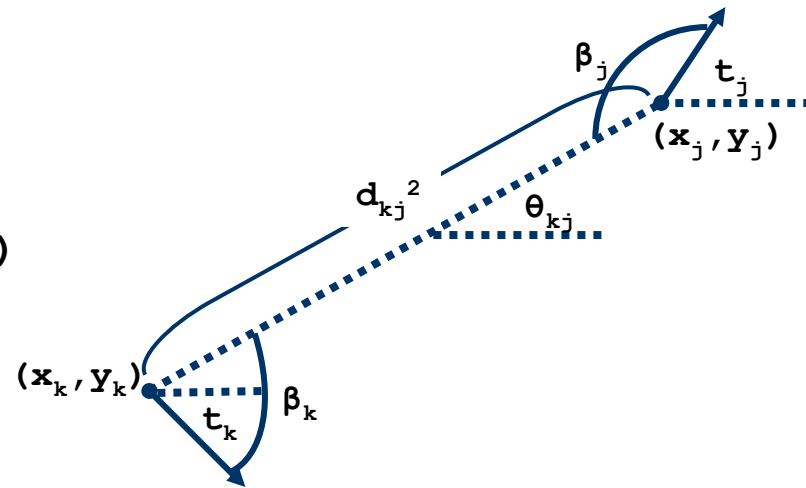
$$\theta_{kj} = \tan^{-1}(\Delta y / \Delta x)$$

$$\beta_k = \theta_{kj} - t_k$$

$$\beta_j = \theta_{kj} - t_j$$

$$\beta_1 = \min(\beta_k, \beta_j)$$

$$\beta_2 = \max(\beta_k, \beta_j)$$



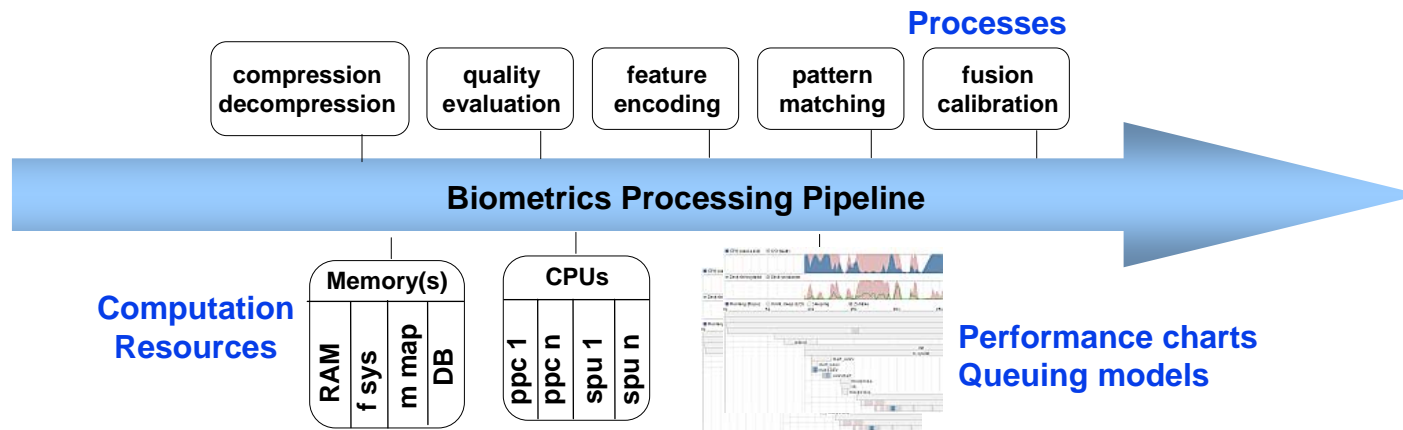
Intra-FP Minutia Comparison Table entries and data size

$$\binom{N_{MP}}{2} \approx \frac{(N_{MP})^2}{2} = 19,900 * 24 (6 \text{ int}) \approx 466 \text{ KBytes}$$

Impacts

- **Software design for use of multi-core processors for high-speed matching (Cell Broadband Engine)**
- **Preliminary feature analysis for database classification, binning and filtering**
- **Preliminary analysis of geometric matching (triangular features versus each minutia)**
- **Requested data analysis and system metrics for sponsor work**

Future Plans



- Continue development of software architecture for benchmarking high-performance biometrics
 - Validate against industry's trend towards multi-core processors and RISC graphics processing units
- Continue analysis of hybrid matching toward the goal of realizing quality-dependent matching
- Publish peer-reviewed results