Biometric Permanence: Definition and Robust Calculation

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Outline

• Motivation and background
• Conceptual overview and study design
• Challenges
• Matched delta methodology
• Simulation setup and results
• Preliminary experimental results
• Discussion and conclusion
Biometric IdMS deployment

• Biometrics increasingly used in long-term Identity Management Systems
  – Biometrically enabled passports
  – “Trusted Traveller” programs (NEXUS)
  – UNHCR refugee program (Accenture BIMS)

• What is the long-term performance of these systems?
Background

• Generally regard biometric features as unique and stable

• Physiological ageing factors depend on modality
  – FACE: skin texture and elasticity
  – IRIS: changes in pupillary diameter

• What is the system level impact of these physiological changes?
ISO 24745 generic RBR model

Binary classification

Imposter

Genuine

Match score

Count (or probability density)

False matches

False non-matches

$t$
Decision Error Tradeoff (DET)

- Decreasing convenience
- Decreasing security
Requirement

• Understand and quantify potential biometric performance degradation over time
  – Increased FMR (decreased security)
  – Increased FNMR (reduced convenience)

• Outcome will inform credential revocation and re-enrollment policies
Conceptual overview

Visit sequence

Score distributions

Decision Error Tradeoff

\[ P_B(\Delta t, \text{FMR}) = \frac{1 - \text{FNMR}(\Delta t)}{1 - \text{FNMR}(0)} \]
Permanence properties

- $P_B$ increases towards unity as $\text{FNMR} (\Delta t)$ tends towards $\text{FNMR}(0)$
  - perfectly permanent template

- $P_B$ decreases towards zero as $\text{FNMR} (\Delta t)$ tends towards unity
  - perfectly impermanent template
Study design & protocol

- >12,000 ISO/IEC standards-compliant enrolments
- >150,000 bitmapped single-finger verification images
- ~500,000 genuine (same subject, same finger) matches
## Visit matrix

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<th>3</th>
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Approximate intervals (in weeks) between visits
“Ideal” ageing behavior

• FNMR (or genuine match score) constant along diagonal of visit matrix ($\Delta t = 0$)

• Monotonic decrease in permanence (FNMR) with absolute time interval $\Delta t$
Baseline variability

Presentation averaged mean genuine scores at $\Delta t = 0$
Factors causing baseline variability

- Test operator training and acclimation
  - Ensuring optimal finger placement
- Test subject acclimation
  - Subject develops better finger placement
- Equipment degradation
  - Damaged or dirty fingerprint capture platen
- Physical environment
  - Humidity, temperature
Heurisitic model

\[ \tilde{S}_{nm} = S_{nm} + a_m + b_n + W_{ji} \]

- True score between \( j^{th} \) biometric in \( n^{th} \) visit and \( i^{th} \) biometric in \( m^{th} \) visit
- Bias specific to \( n^{th} \) verification visit
- Bias specific to \( m^{th} \) enrollment visit
- Presentation averaged noise term
“Matched Delta” method

- Collect biometric templates AND verification presentations at each visit
- Match $\tilde{s}_{nm}^{ji}(\Delta t_{ji})$ and $\tilde{s}_{mn}^{ij}(\Delta t_{ij})$
- Average the forward-in-time ($ji$) and backward-in-time ($ij$) match scores
- Substantially eliminates the bias terms $a_m, b_n$
Visit matrix

Base1

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Base2

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Simulation goals

• Demonstrate application of method
  – Simulate large number of matches
  – Known distribution (Rayleigh)
  – Allows us to predict $P_B(\Delta t, FMR)$ analytically

• Establish convergence between new method and naïve calculation
  – Simulate an ensemble of 8-visit studies
  – Average converges to Matched Delta result?
Simulation results

- raw score distribution
- matched delta method
- analytical (Rayleigh distributions)
Ensemble convergence
Results – typical device

Permanence

Baseline ($\Delta t = 0$) score histogram

Device ID 02: capacitive semiconductor
Results – low ageing

Permanence

Baseline ($\Delta t = 0$) score histogram

Device ID 03: optical (single spectral)
Conclusion

• Biometric template ageing has serious operational implications
• It is hard to measure because of factors such as environment and acclimation
• Proposed an operational definition of Biometric Permanence $P_B(\Delta t, FMR)$
• Demonstrated an effective “Matched Delta” method to evaluate it
• Now applying to measured data