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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

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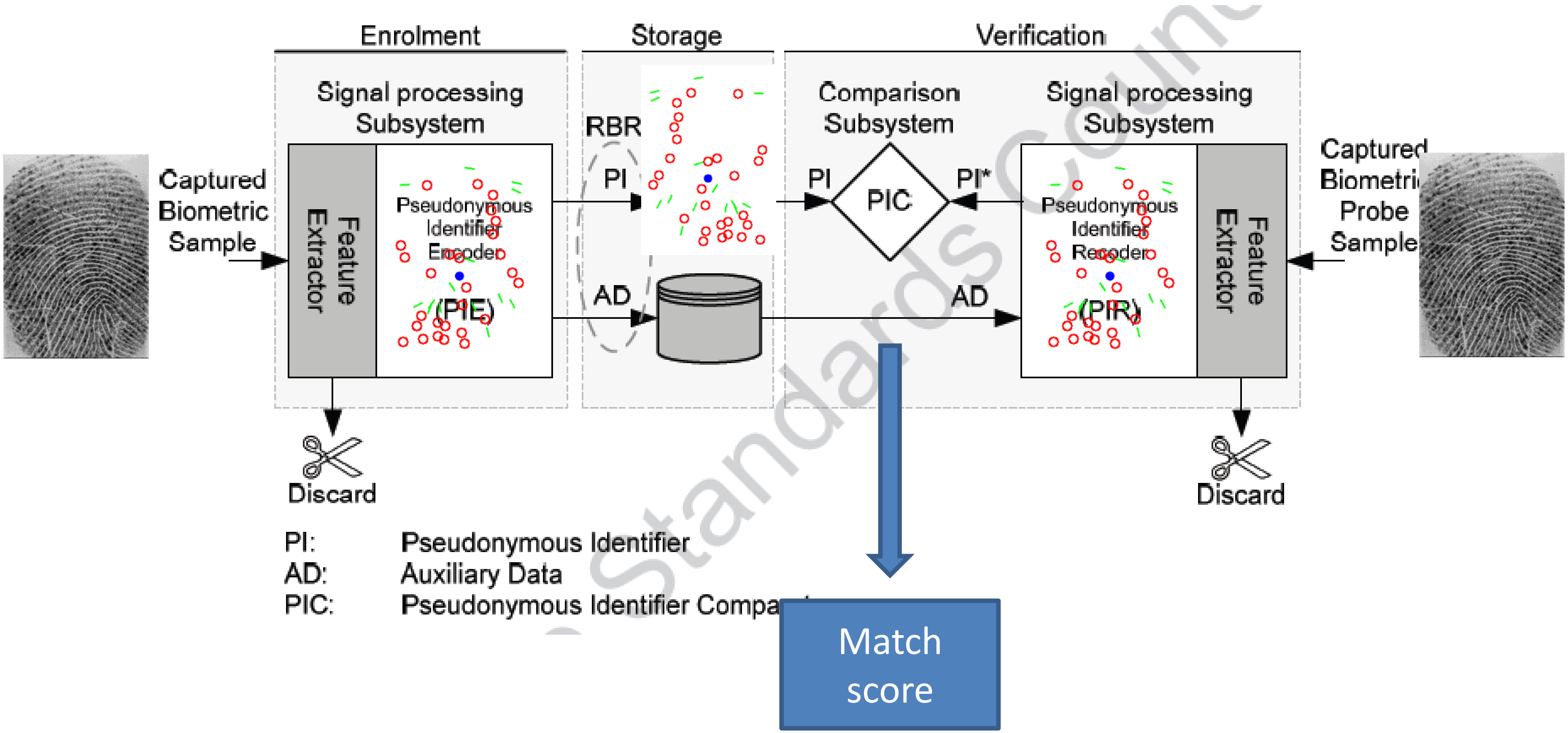
Biometric IdMS deployment

- 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



SOURCE: ISO/IEC 24745 “Information technology — Security techniques — Biometric information Protection” (2011)

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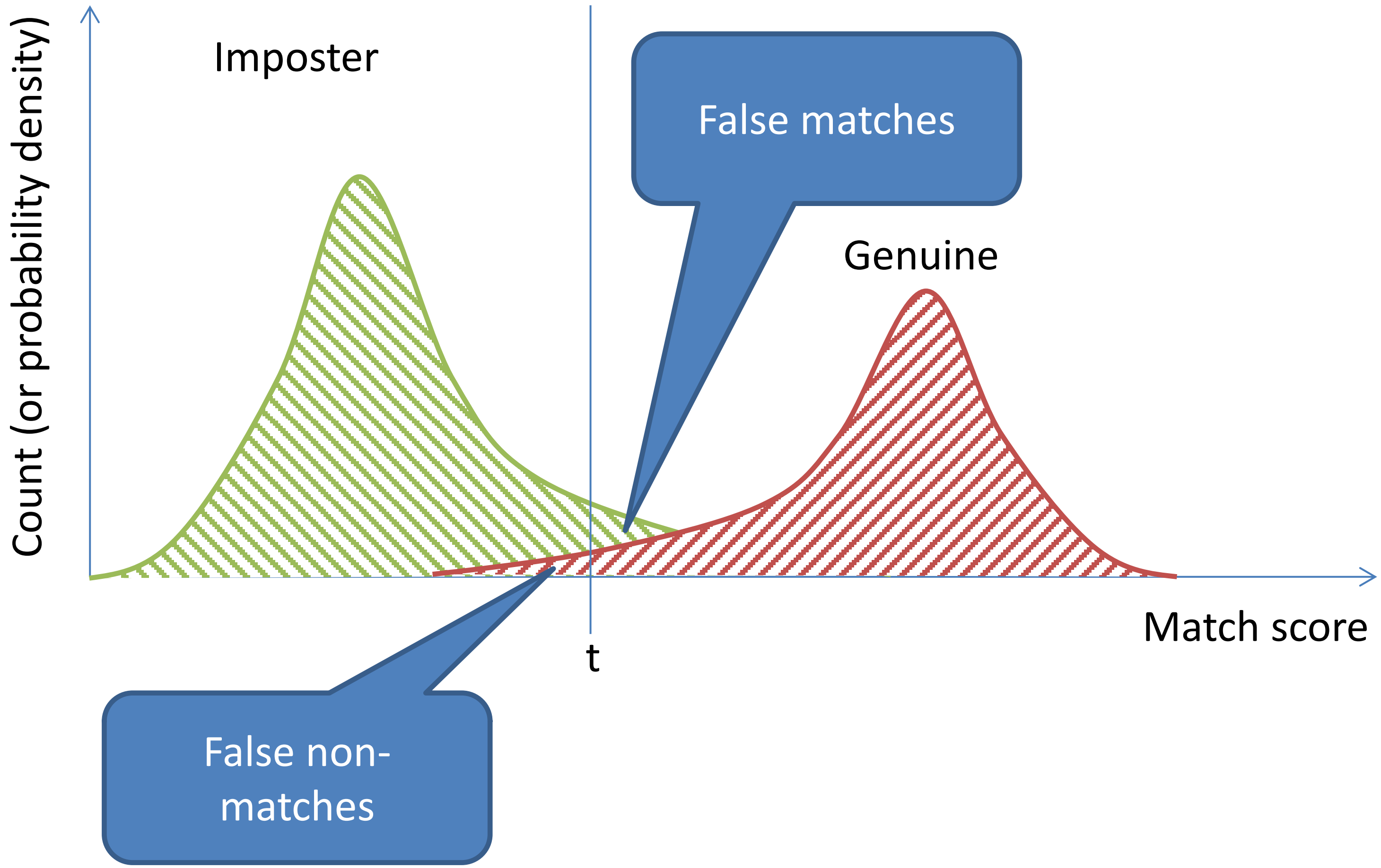
Binary classification



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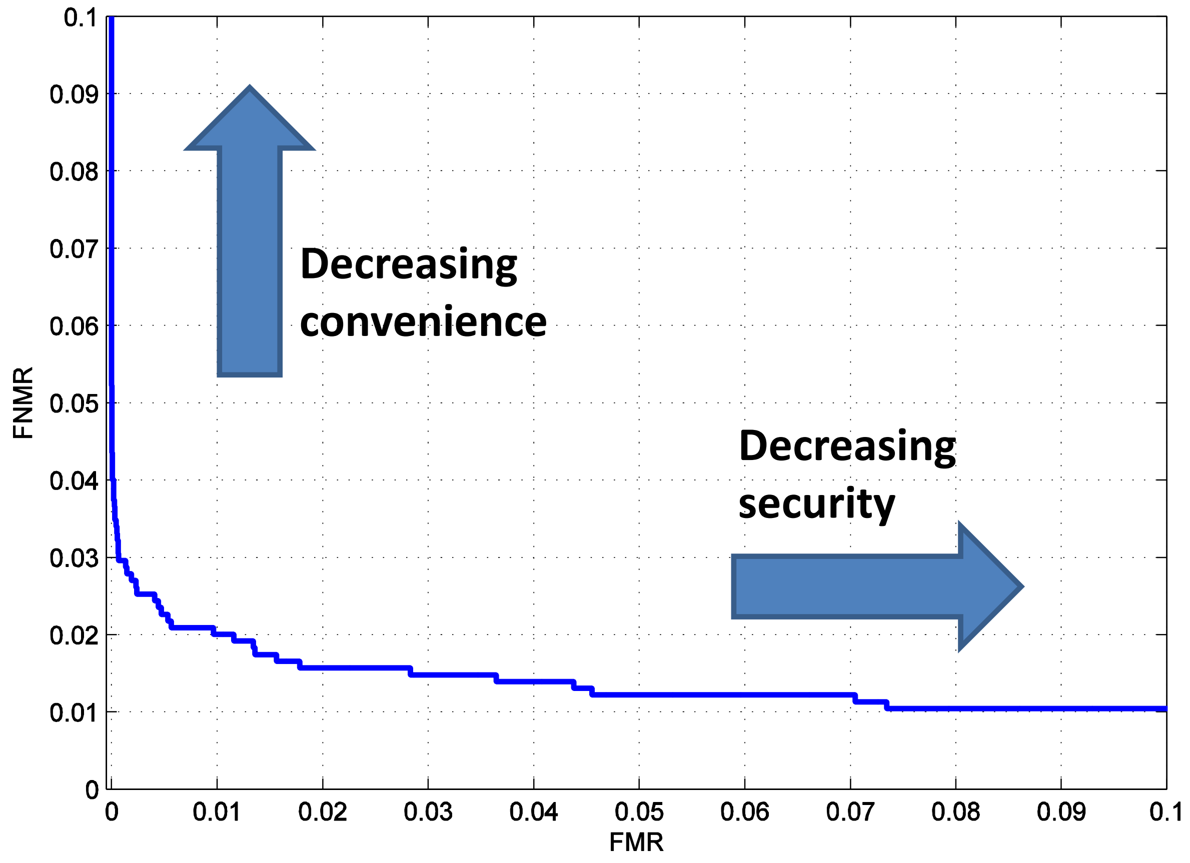
Decision Error Tradeoff (DET)



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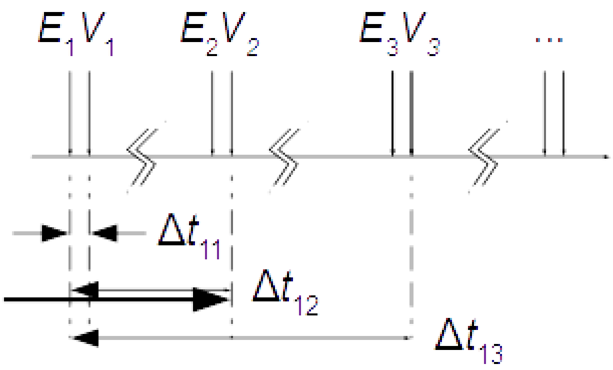
Requirement

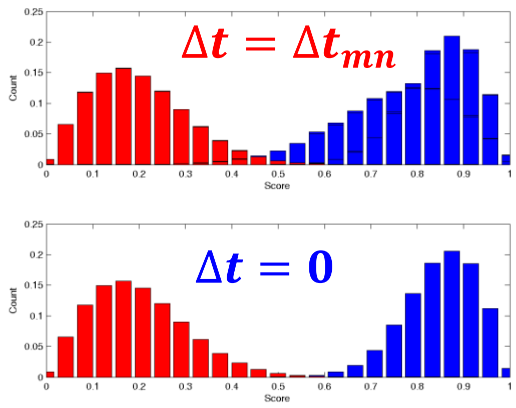
- Understand and quantify potential biometric performance degradation over time
  - Increased FMR (decreased security)
  - Increased FNMR (reduced convenience)

- Outcome will inform credential revocation and re-enrollment policies

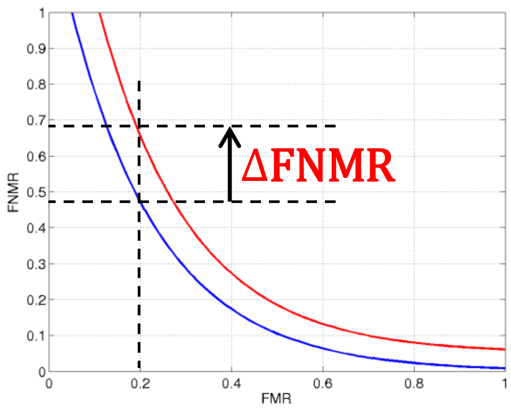
Conceptual overview



Visit sequence



Score distributions



Decision Error Tradeoff

$$P_B(\Delta t, \mathrm{FMR}) = \frac{1 - \mathrm{FNMR}(\Delta t)}{1 - \mathrm{FNMR}(0)}$$

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Permanence properties

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

- P_B decreases towards zero as $\mathrm{FNMR}(\Delta t)$ tends towards unity
  - perfectly impermanent template

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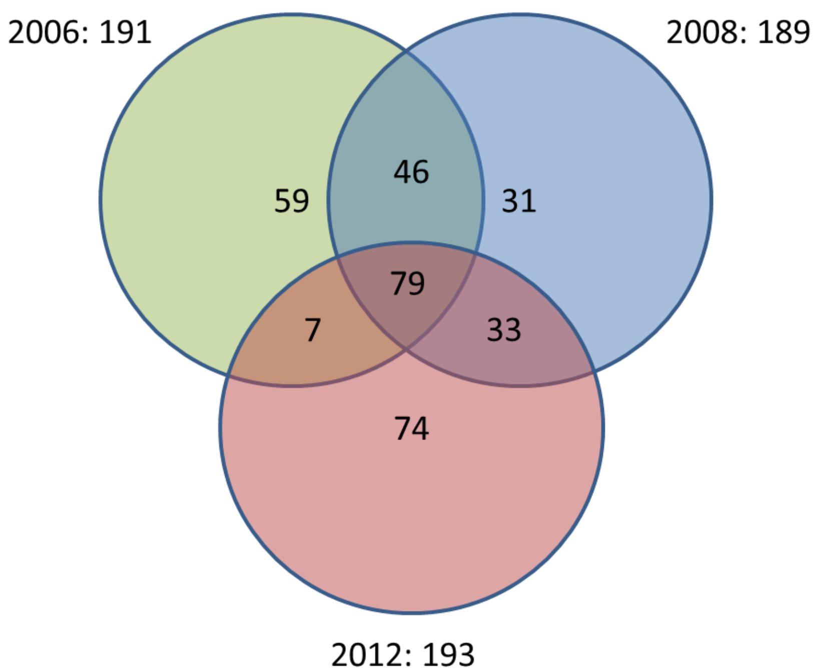
Study design & protocol



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

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Visit matrix

	Verify	1	2	3	4	5	6	7	8
Enrol		2006-02	2006-03	2008-10	2008-10	2012-02	2012-03	2013-03	2013-04
1	2006-02	0	2	137	140	314	318	369	374
2	2006-03	-2	0	135	137	312	315	367	371
3	2008-10	-137	-135	0	2	176	180	232	236
4	2008-10	-140	-137	-2	0	174	178	230	234
5	2012-02	-314	-312	-176	-174	0	4	55	60
6	2012-03	-318	-315	-180	-178	-4	0	52	56
7	2013-03	-369	-367	-232	-230	-55	-52	0	4
8	2013-04	-374	-371	-236	-234	-60	-56	-4	0

Approximate intervals (in weeks) between visits

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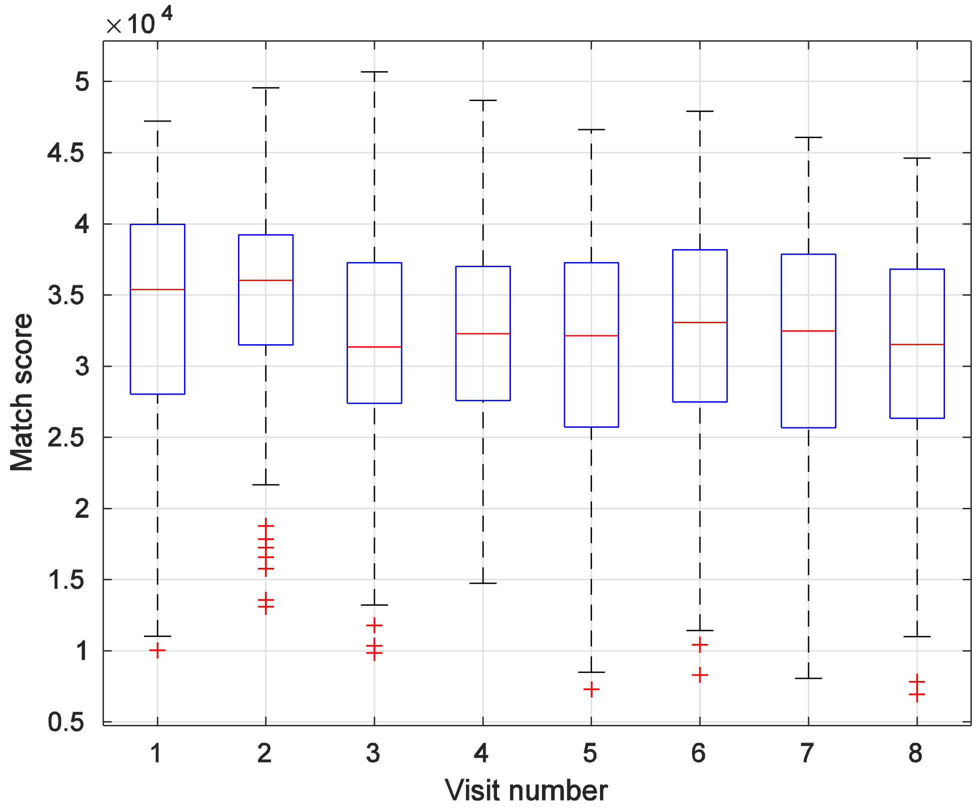
"Ideal" ageing behavior

- FNMR (or genuine match score) constant along diagonal of visit matrix ($\Delta t = 0$)
- Monotonic decrease in permanence (FNMR) with absolute time interval Δt

Baseline variability



Presentation averaged mean genuine scores at $\Delta t = 0$

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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

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Heuristic model

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

$$\bar{s}_{nm}^{ji} = s_{nm}^{ji} + a_m + b_n + \bar{W}^{ji}$$

Bias specific to m^{th} enrollment visit

Presentation averaged noise term

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"Matched Delta" method

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

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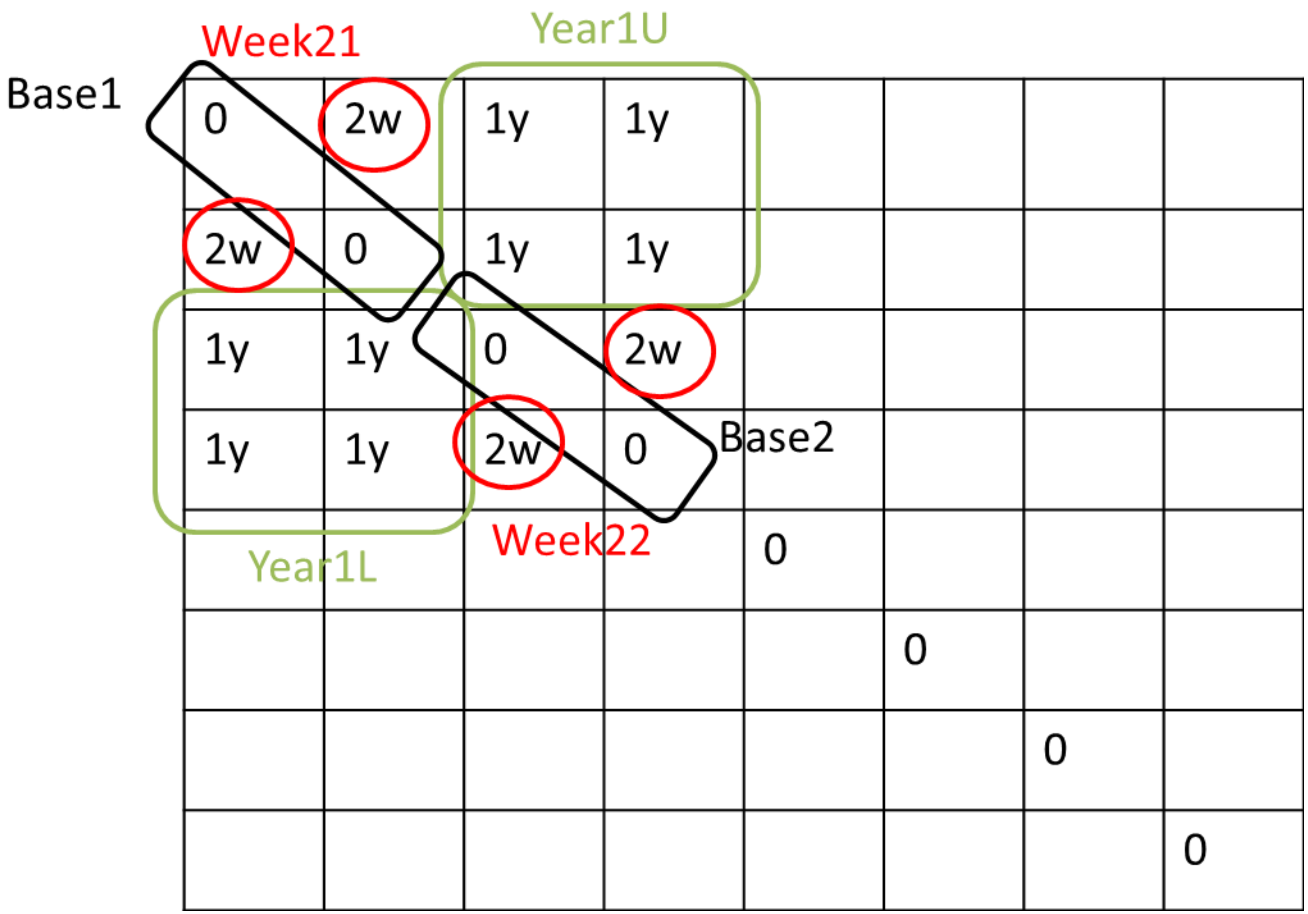
Visit matrix



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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?

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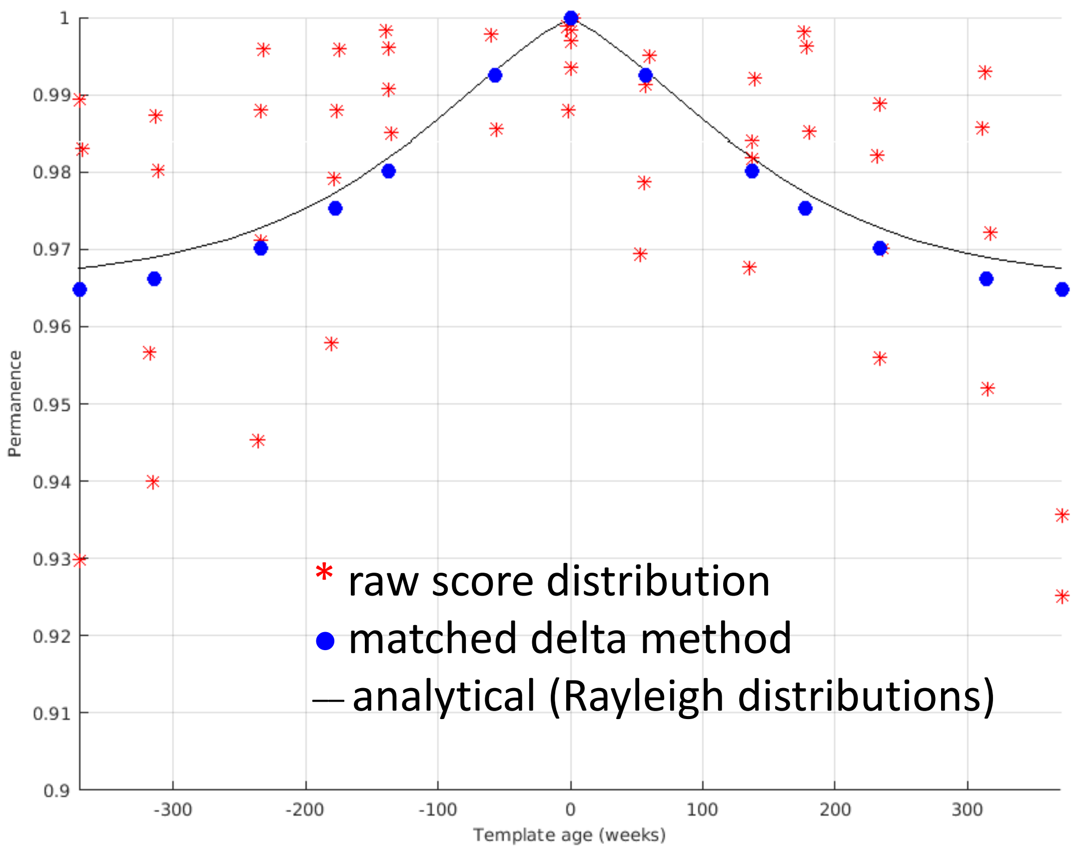
Simulation results



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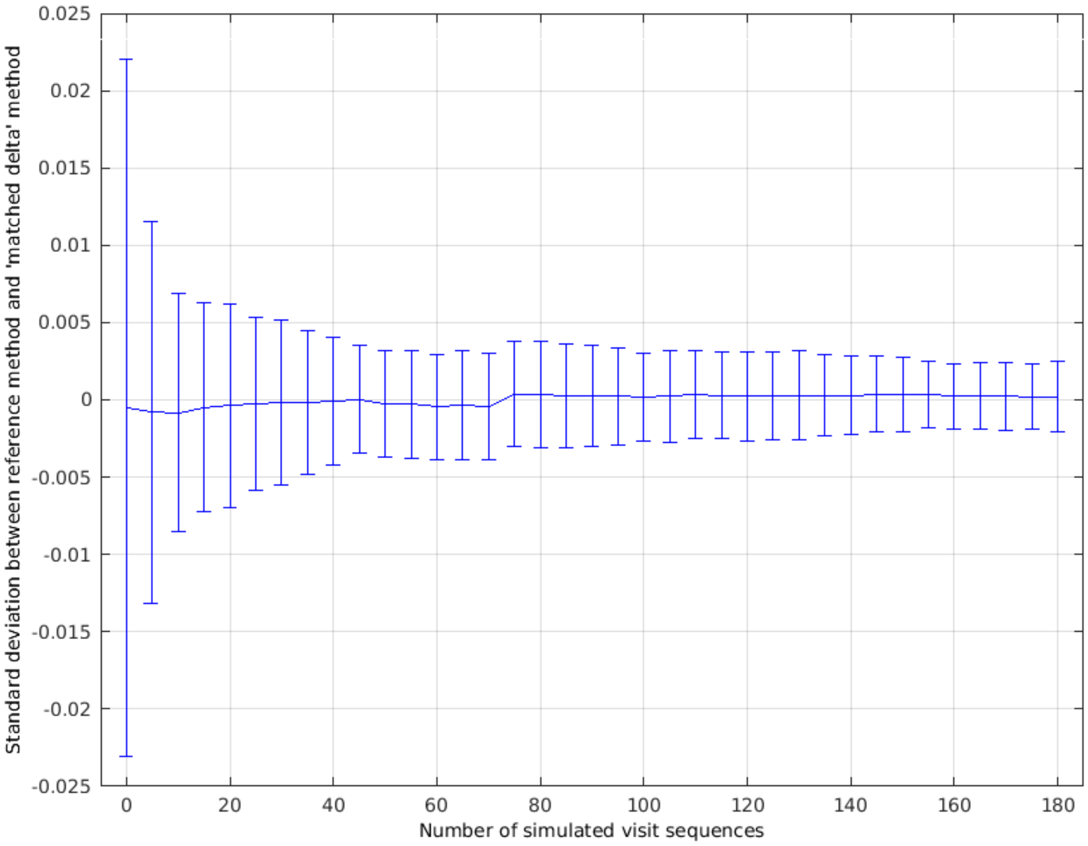
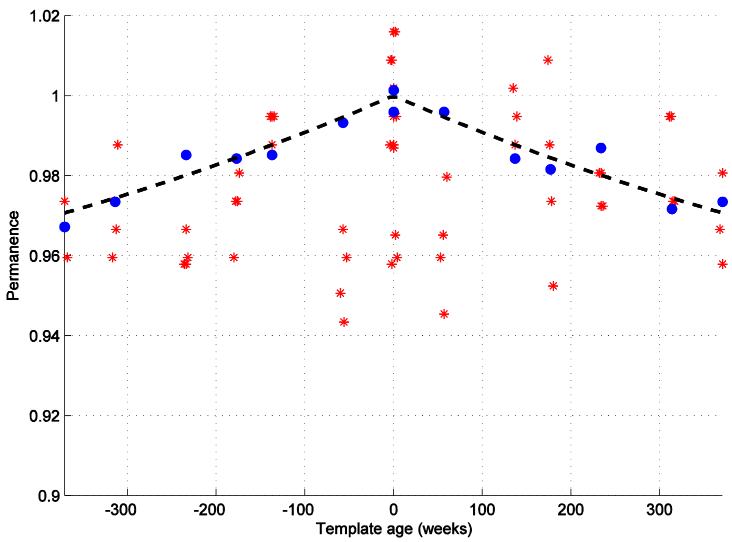
Ensemble convergence

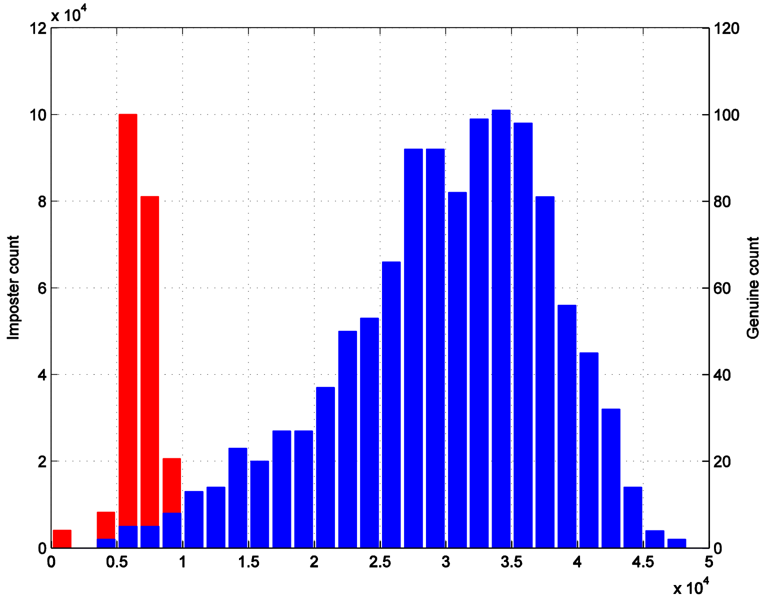


Results – typical device

Permanence



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



Device ID 02: capacitive semiconductor

Results – low ageing

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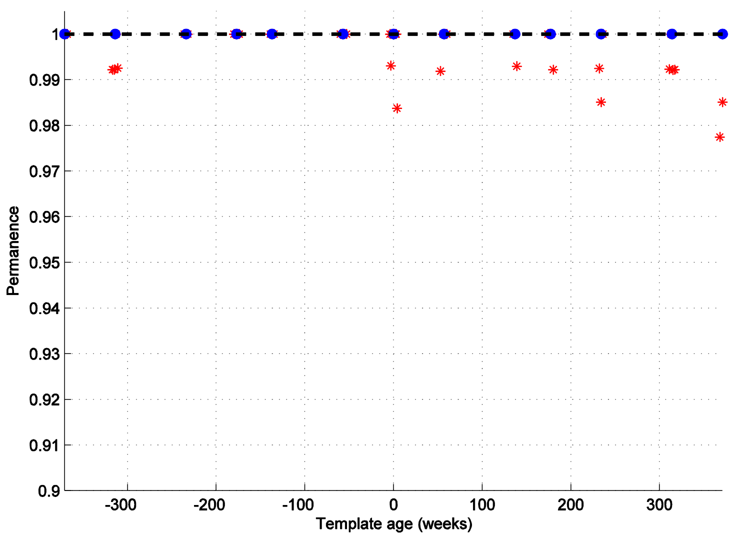
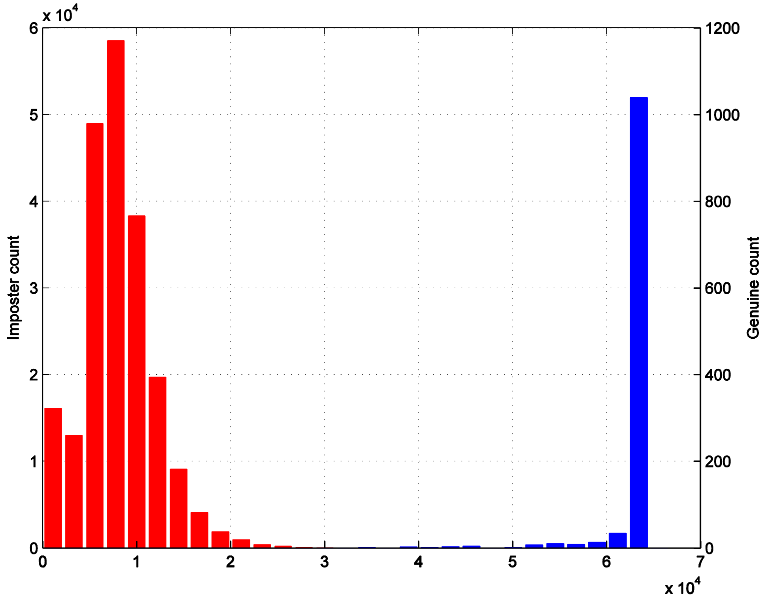
Permanence



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