Testing Trajectories

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International Biometric Performance Conference 2012

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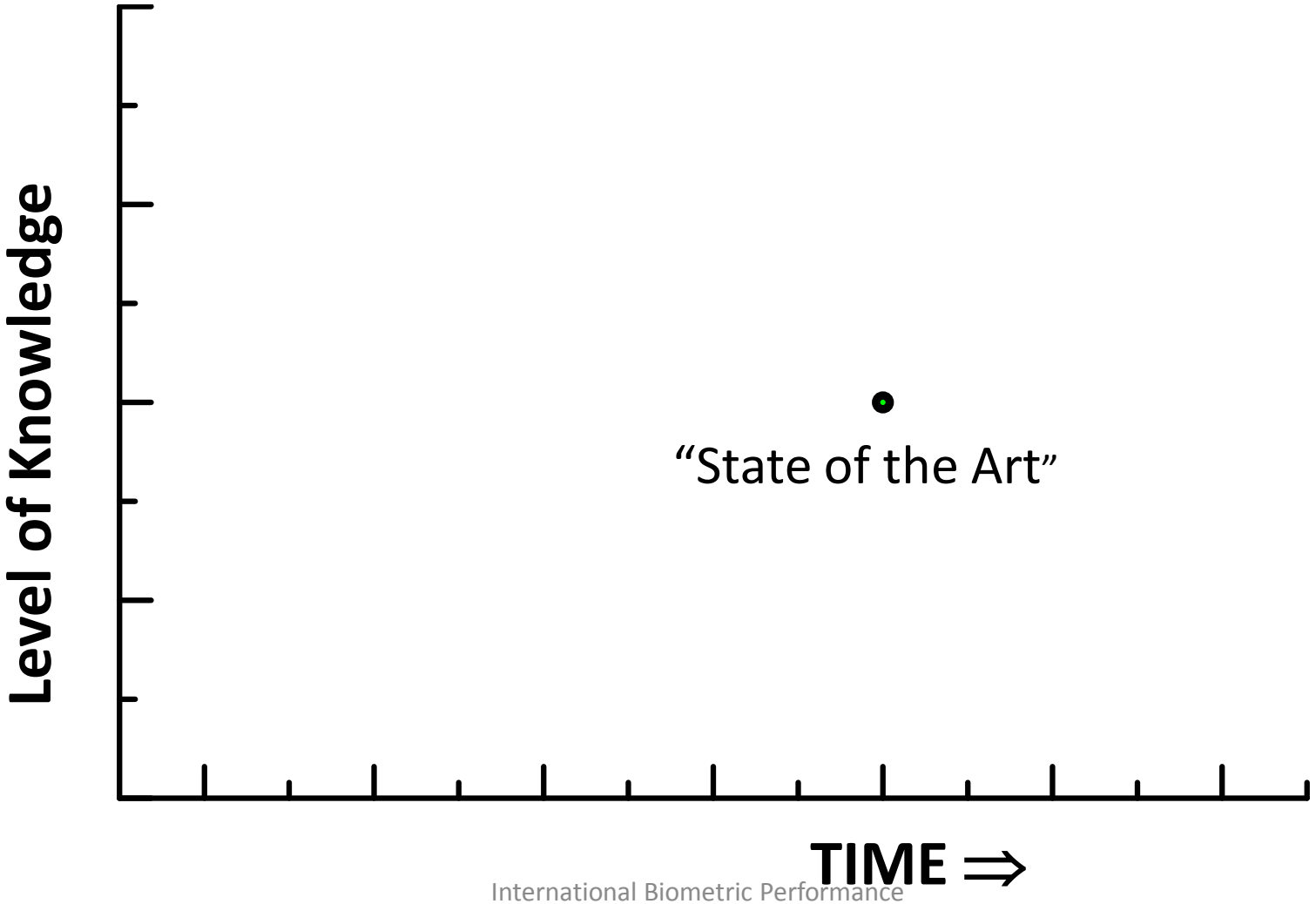

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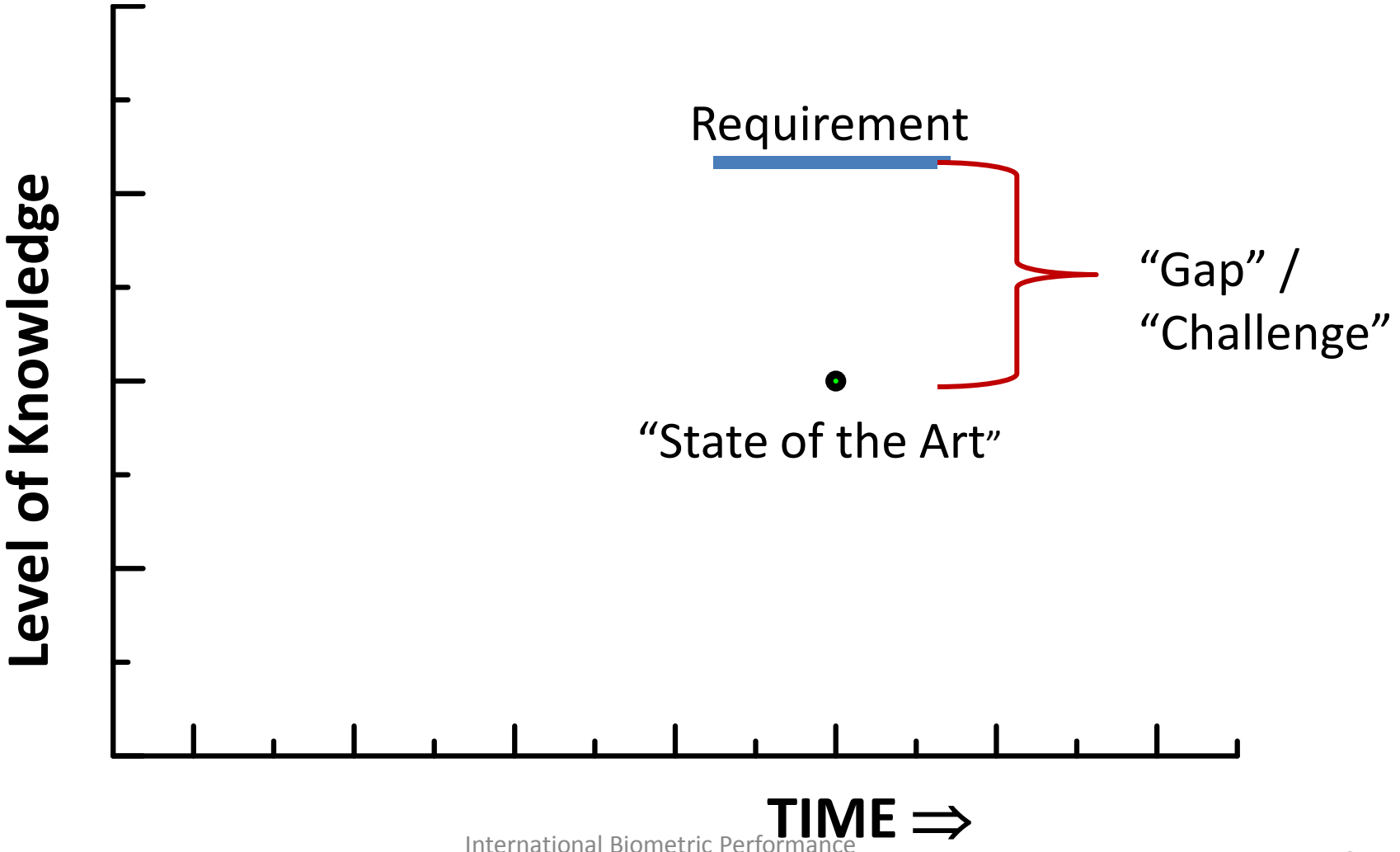

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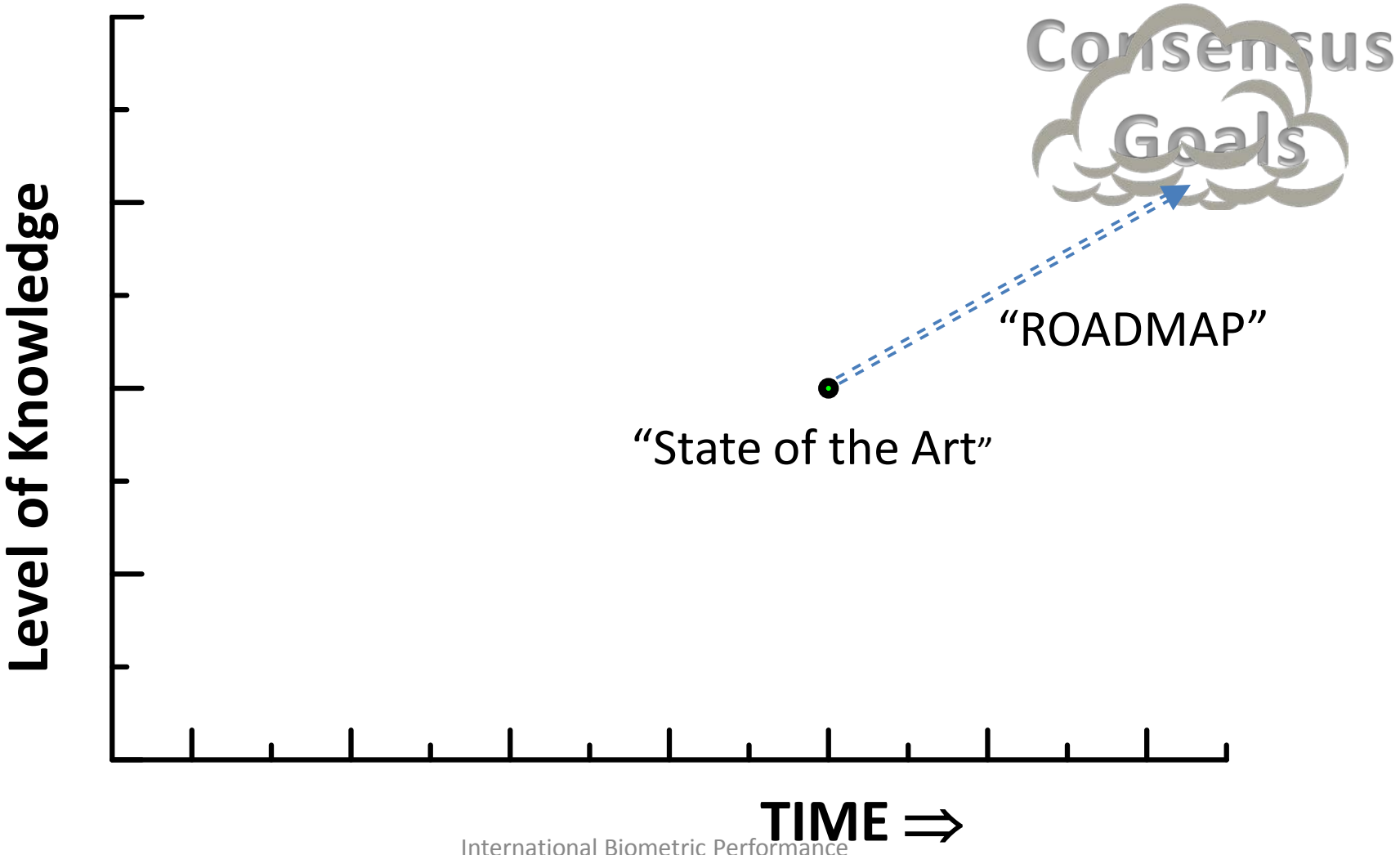

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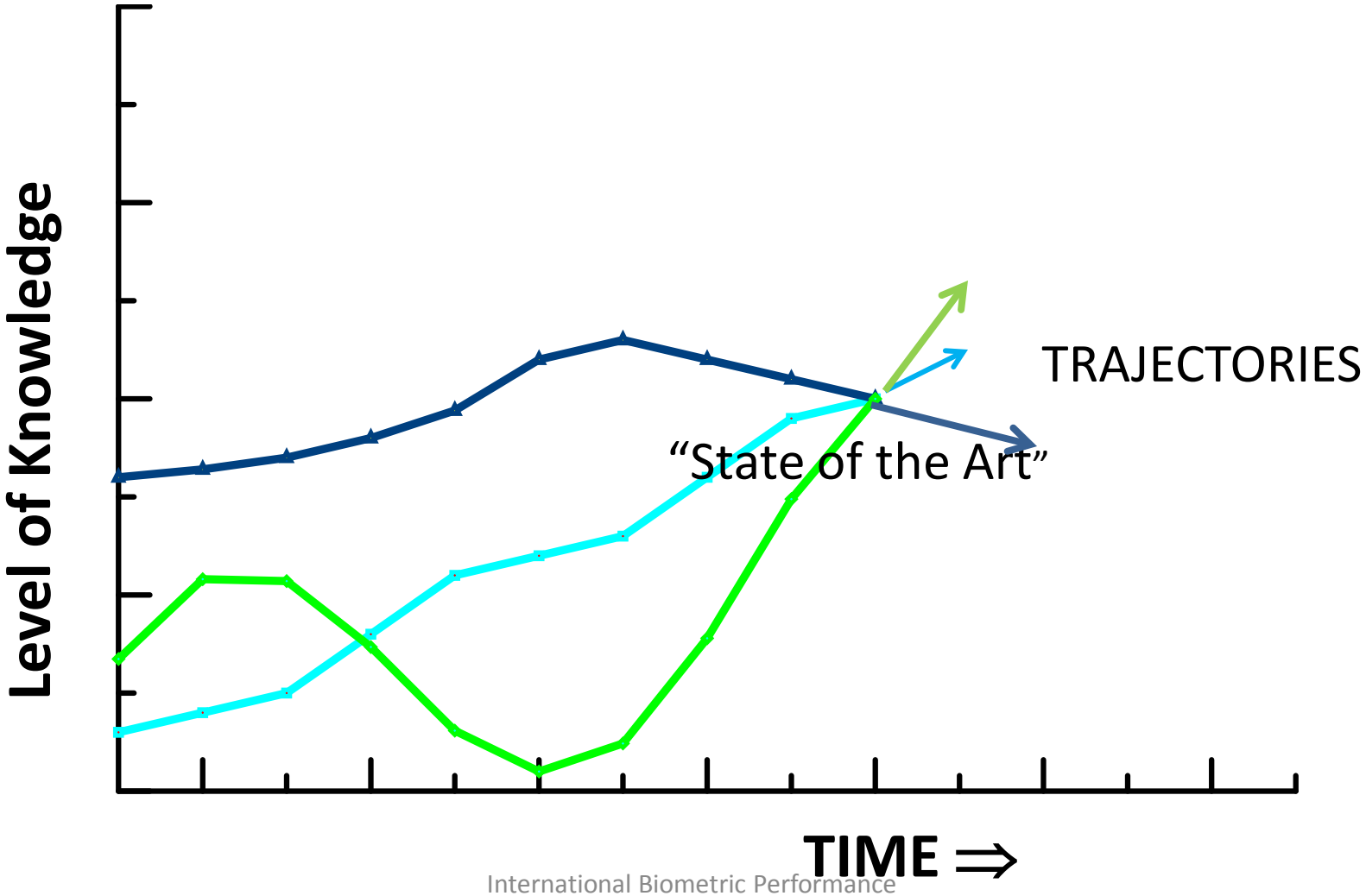


Is Scientific Knowledge Cumulative?

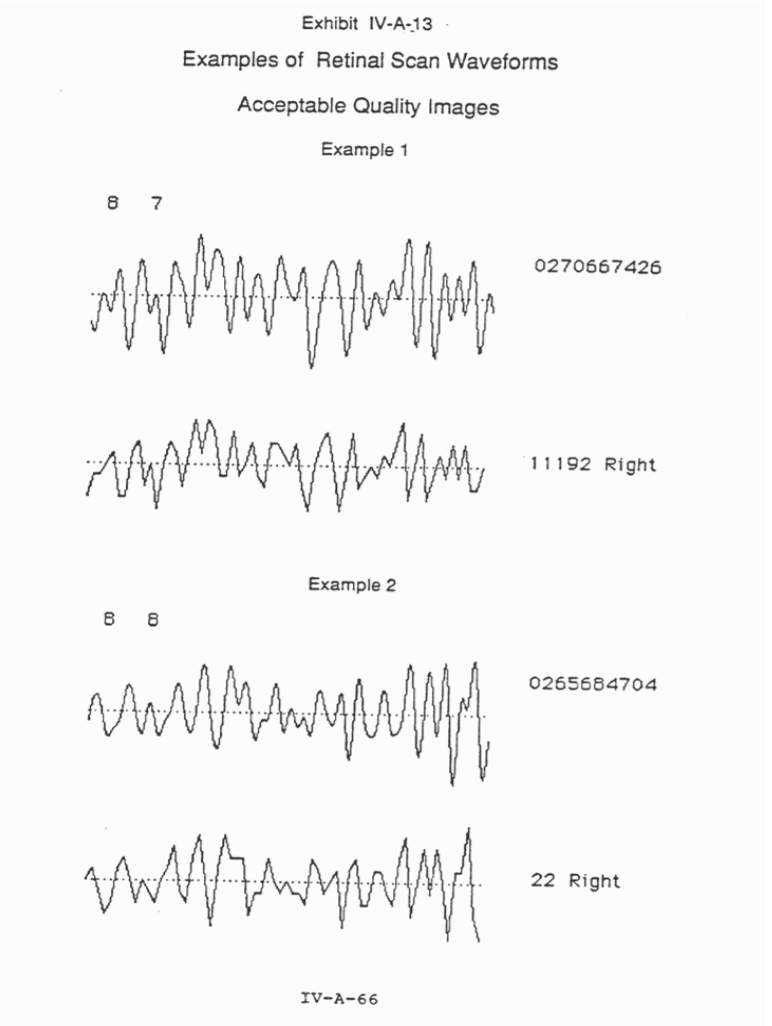
- Contentious issue in the late 20th Century
- IMHO: Yes, but not on a local, short-term level.
- In general, we know more now than before, but….
- In specific areas, over short periods, we know less.
- We learn, then forget or discard
- Why?
  - Our agenda is determined in a social context:
    - Fads
    - Economics
    - Perceived needs
    - Chance of fame and fortune …
  - We change and our values change

A Partial List on References for this Talk

- Ernest Nagel, The Structure of Science, 1961
- Thomas Kuhn, The Structure of Scientific Revolutions, 1962
- Ian Hacking, Representing and Intervening, 1982
- Ernan McMillan (ed.), The Social Dimensions of Scientific Knowledge, 1992
- Elizabeth Anderson, “Feminist Epistemology: An interpretation and a defense”, 1995

Things We Used to Know, But Have Forgotten

- Retinal scanning
- Facial thermography
- Finger circumference
- Comparative modality testing
- Credit Card applications



Two Upward Testing Trajectories

- Vulnerability assessment
- Estimating large-scale system performance

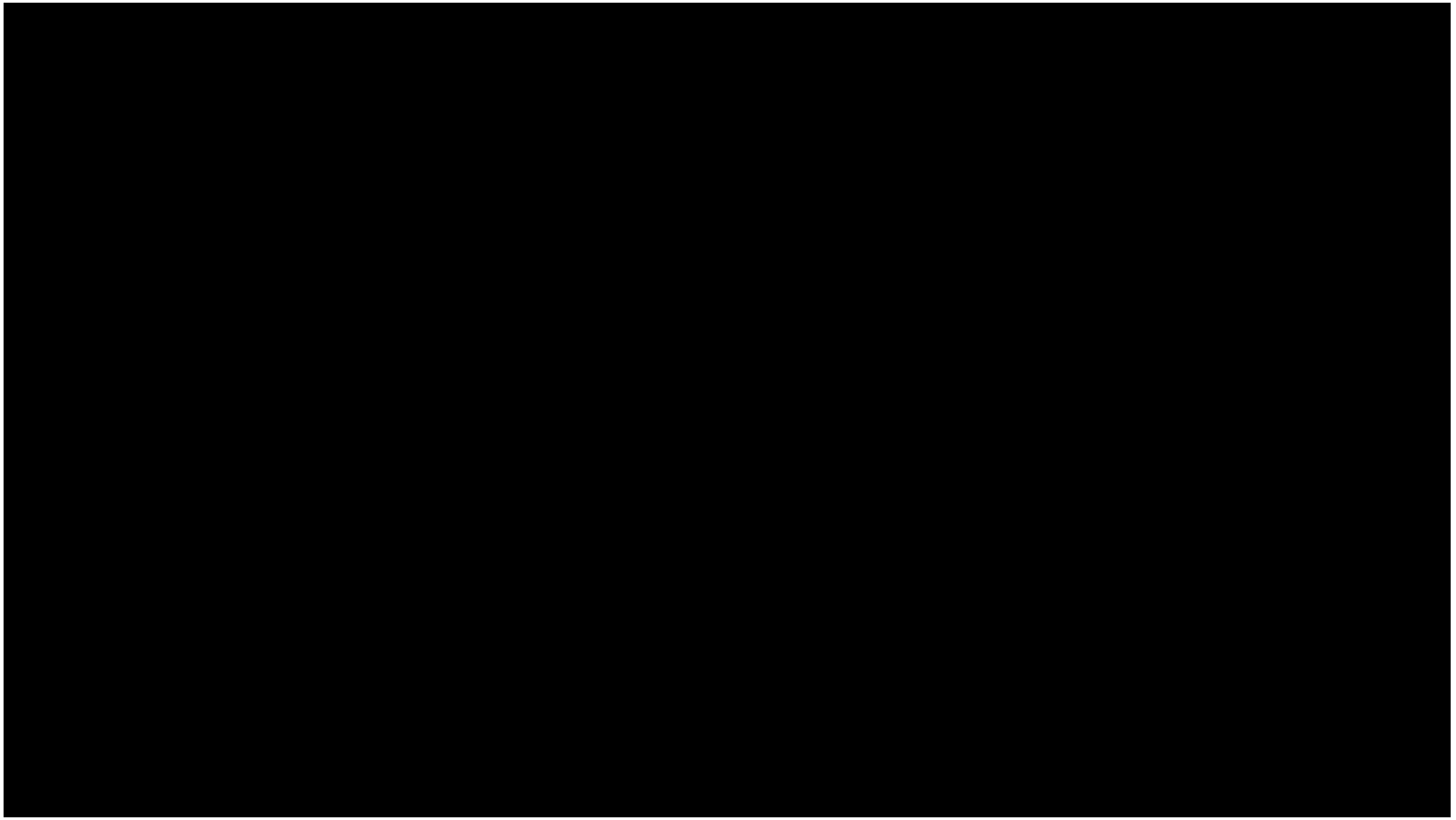
Vulnerability Assessment – "Pre-History"

See Geller B, Almog J, Margot P, Springer E. (1999). A Chronological Review of Fingerprint Forgery, Journal of Forensic Sciences; 44, 5, 963-968

- Ehmer G., Ein Gaunertrick gegen die Daktyloskopie, Arch Kriminal—Anthropol Kriminalistik 1909;200.
- Carlson M., Fingerprint can be forged. Virginia Law Register 1920;5.
- Lee HC, Easy to detect finger forgeries. Fingerprint Magazine 1928;10(Pt3):12–3.

Media Interest – 1970s

- “Diamonds are Forever” 1971



Vulnerability Assessment – 1970s

- R.C. Lummis and A. Rosenberg “Test of an Automatic Speaker Verification method with intensively trained mimics”, JASA (51), p.131(A), 1972
- Kibbler, G.O.T.H, “Evaluation of the Identimat 2000 Hand Geometry Identifier”, Mitre Corp., Oct., 1972
- D.E. Raphael and J.R. Young, “Automated Personal Identification”, SRI, International (1974)
- “Guidelines for Evaluation of Techniques for Automated Personal Identification”, Federal Information Processing Standards Publication 48, NBS, April 1977

RFC Systems – mid-1970s

- Work on “live/drunk/drugged finger” detection

1980s -Vulnerability Assessment Goes Classified

- The Secret Art

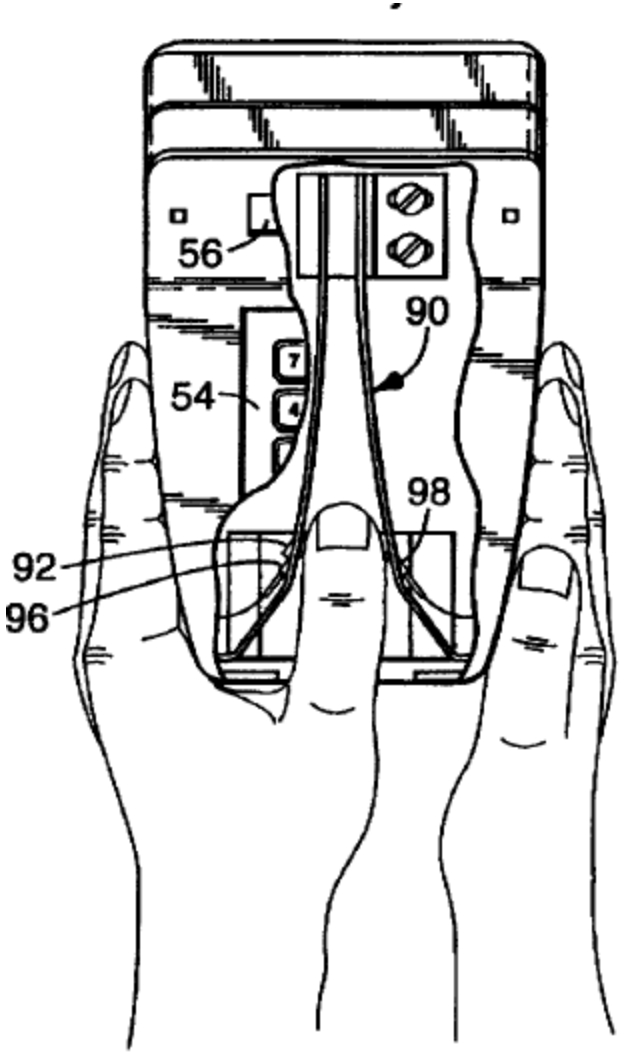
Yes, art -- “The absence of evidence is not evidence of absence”

  - Sandia: George Ingram and Blackhat Analysis
  - Mitre
  - SRI

- Identix commerical use of “live finger” detection based on red -> white color shift with finger pressure
  - Touchblock – ??? (nobody remembers)

Vulnerability Assessment -1990s

- J. Daugman, T-PAMI, 1993
- Schiphol Travel Pass
- vander Putte and Keuning
- German Federal Office of Information Security (BSI)
- 3M Federal Systems
  - Osten, Carim, Arneson, and Blan, "Biometric, personal authentication system", Feb 17, 1998 U.S. Patent 5719950
- Missing: US National Biometric Test Center

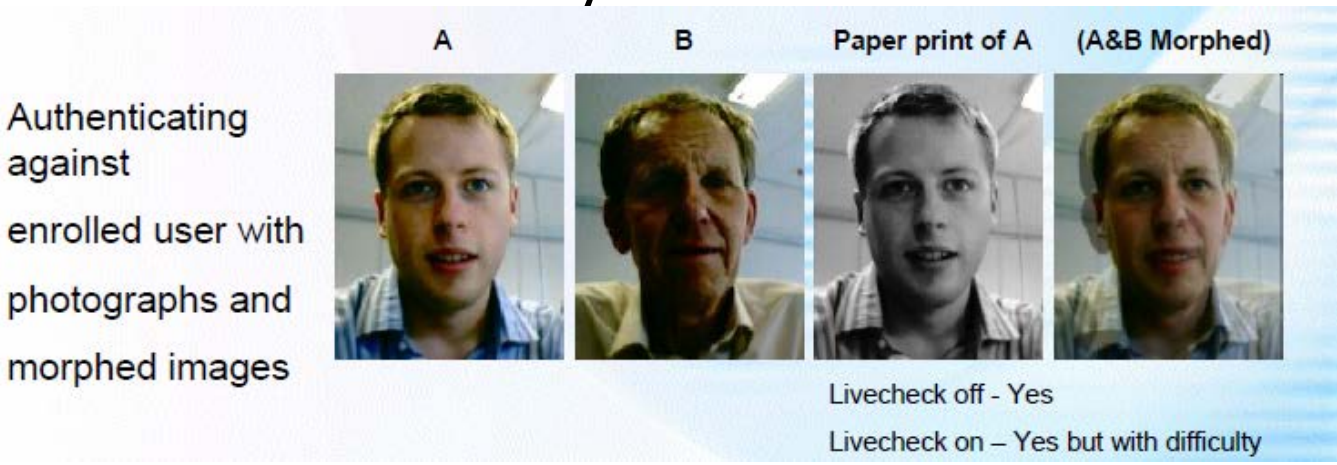


NSA Goes Public with Vulnerability Assessment

CBS “60 Minutes II”, Jan. 24, 2001

Vulnerability Assessment -- 2000s

- ANSI X9.84 - 2003, “Biometrics Management and Security For The Financial Services Industry”
- Fraunhofer
- CESG



- Common Criteria Recognition Arrangement, ISO/IEC 15408: 1998
  - Biometric Protection Profiles
    - CESG
    - BSI
    - BMO
- ISO/IEC 19792:2009 “Security Evaluation of Biometrics”

Right Here, Right Now

- Multiple representational frameworks
  - BSI
  - Fraunhofer
  - Common Criteria
  - ISO/IEC 30107
  - Biometrics Institute
- Satellite Workshop (Friday): Artefact, Liveness, and Suspicious Presentation Detection

Trajectory 2: Estimating performance of Large-scale Systems

- Reductionist approach for Philippines SSS, 1997
  - The model

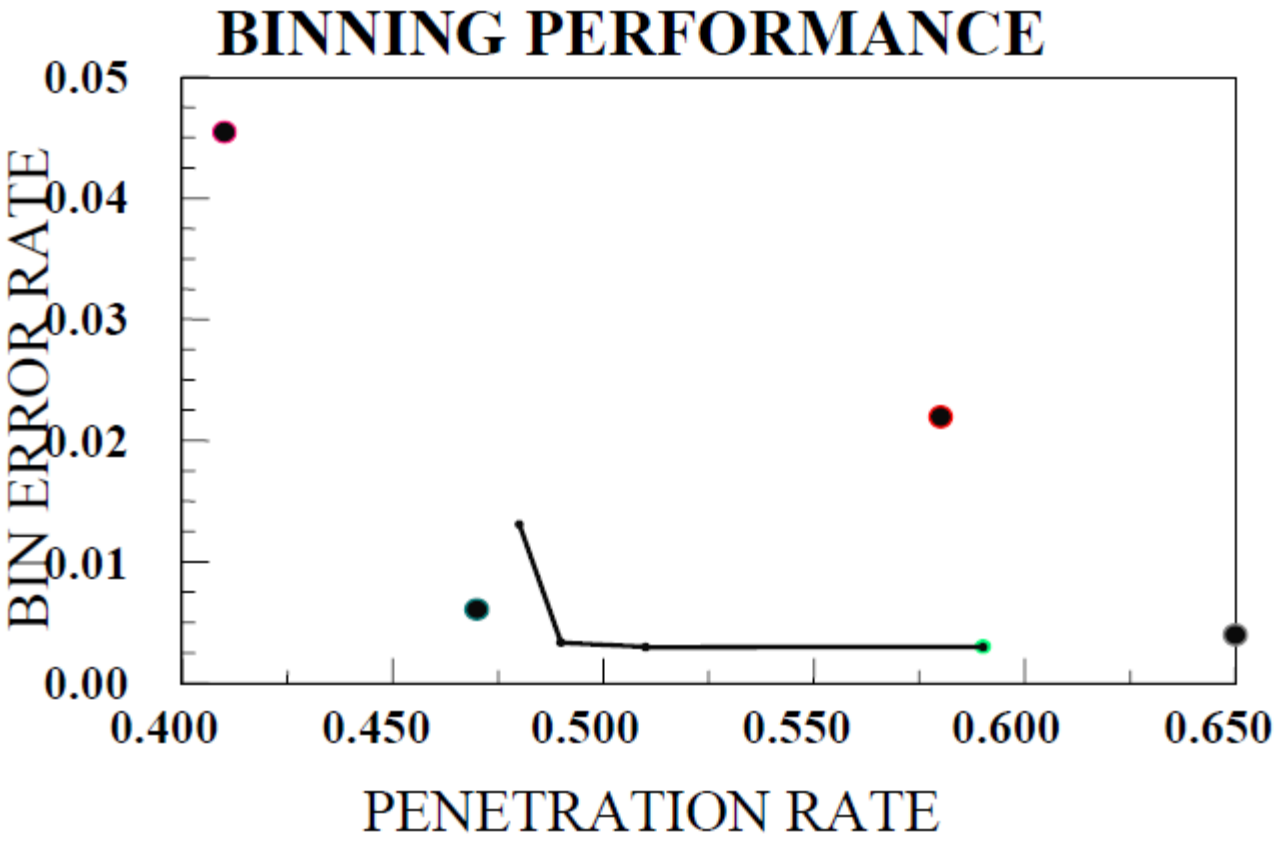
  "Under the simplifying, but approximate, assumption of statistical independence of all errors, (the) independent variables are bin error rate, penetration rate, sample-template ('genuine') and 'impostor' distance distributions, number of active templates or user models in the database, N, and the number of samples submitted for each transaction, M"
  - When N = 1, equations must degenerate to "verification" system.

Bernoulli Assumptions, Binomial Results

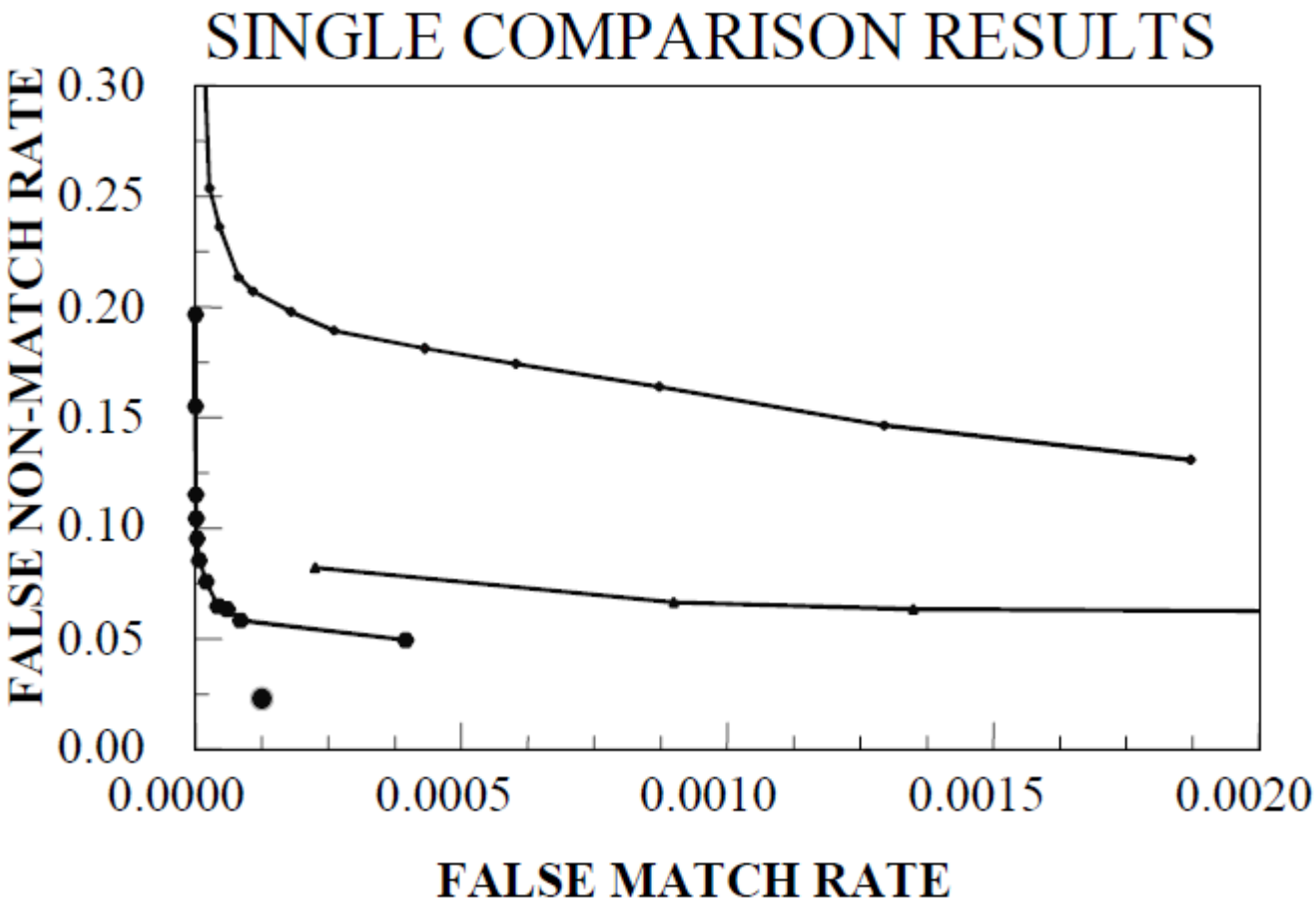
$$FNM_{sys} = \varepsilon_{ensemble} + [1 - \varepsilon_{ensemble}] \prod_{i=1}^{m} \left[1 - (1 - FNM_i) \sum_{j=Q-1}^{T-i} \binom{T-i}{j} (1 - FNM_U)^j (FNM_U)^{T-i-j} \right]$$

$$FMR_{sys} = 1 - \prod_{i=1}^{m} \left[1 - FMR_i * \sum_{j=Q-1}^{T-i} \binom{T-i}{j} FMR_U{}^j (1 - FMR_U)^{T-i-j} \right]^{N*P_i}$$

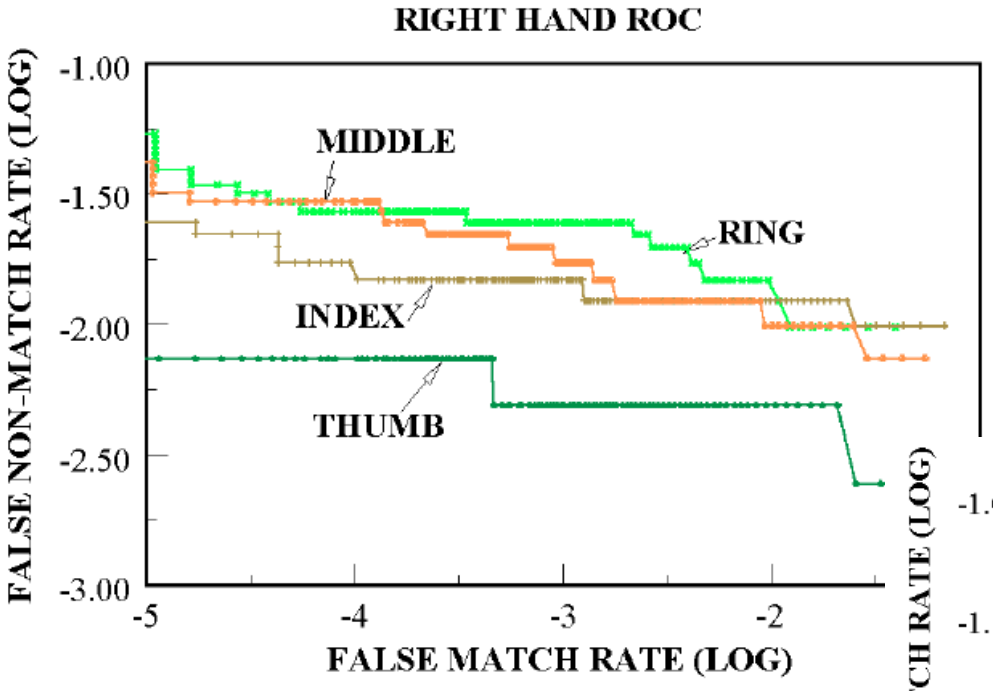
Estimating the Parameters (forgotten)

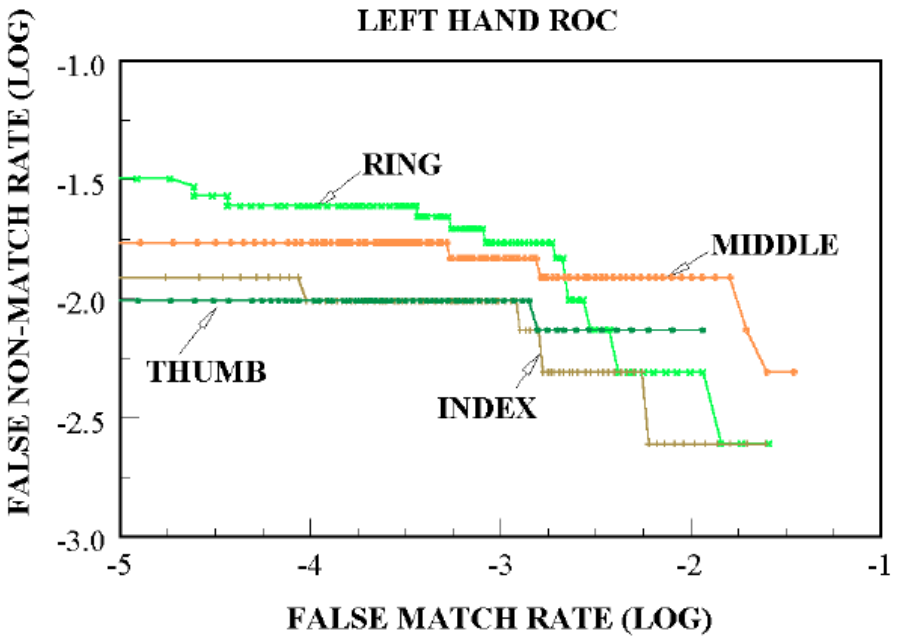


Estimating the Parameters (remembered)



Finger Variability





Penetration Rate Correlations

TABLE 4: TWO-FINGER BINNING STATISTICS

Finger	Error Rate	Error if independent	Penetration Rate	Penetration if independent	
				FBI Data	Test Data
Thumb	0.005	0.005	0.52	0.30	0.47
Index	0.007	0.007	0.25	0.19	0.20
Middle	0.015	0.019	0.55	0.71	0.49
Ring	0.017	0.017	0.55	0.44	0.49

TABLE 5: MULTIPLE-FINGER BINNING STATISTICS

Fingers	Error Rate	Error if independent	Penetration Rate	Penetration if independent	
				FBI Data	Test Data
Four: Thumb and index	0.012	0.012	0.15	0.059	0.093
Eight: Thumb index, middle, ring	0.040	0.048	0.08	0.018	0.022

Further Reduction

- M. E. Schuckers, "Using the beta-binomial distribution to assess performance of a biometric identification device," *International Journal of Image and Graphics, 2003.*
- Because ….each individual will have their own probability of success, then p, the usual binomial parameter for probability of success, is not the same for each user. Thus, the binomial is not appropriate for assessing the performance… when combining outcomes from multiple users. Consequently, we need a model that allows for variability in the probability of success among individuals and that allows for the possibility that trials by a given individual are not independent. One such model is the Beta-binomial model or, more formally, the product Beta binomial.

$$f(\vec{x}|\alpha,\beta,\vec{n}) = \int f(\vec{x},\vec{p}|\alpha,\beta,\vec{n})dp = \int f(\vec{x}|\vec{p},\vec{n})\, f(\vec{p}|\alpha,\beta)dp$$

$$= \prod_{i=1}^{m} \binom{n_i}{x_i} \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} \frac{\Gamma(\alpha+x_i)\Gamma(\beta+n_i-x_i)}{\Gamma(\alpha+\beta+n_i)}$$

- Where there are n individuals tested m times and α,β are parameters of the Beta distribution of p among the individuals

An Empirical Approach by NIST

- Wilson, et al, “Fingerprint Vendor Technology Evaluation 2003”, NISTIR 7123, June 2004
- “Some biometric models assume that the false accept rate grows linearly with gallery size when true accept rate is kept constant. This assumption was tested by comparing the results of verification and open-set identification ROCs.” (Not quite correct)
- “……Figure 19 and Figure 20 is consistent with the observation that the false accept rate grows linearly with gallery size, and the true accept rate remains constant.”

A Listing of Alternative Representations

- Jarosz, Fondeur, Dupré, "Large-scale Identification System Design" (2005)
  1. Extrapolation from experience
  2. Identification as succession of N verifications
  3. Extrapolation from extreme value
  4. Extrapolation when distance can be modeled

The influence of classification on reductionist models:

FMR = f(binning)

Additional Work

- Schuckers, ME "A parametric correlation framework for the statistical evaluation and estimation of biometric-based classification performance in a single environment," *IEEE Transactions on Information Forensics and Security* 4 (2009), 231-241
- Walter Scheirer, Anderson Rocha, Ross Micheals, and Terrance Boult, "Meta-Recognition: The Theory and Practice of Recognition Score Analysis", IEEE T-PAMI, Nov. 2010

Right Here, Right Now

Which representation?

- Michael Schuckers, “Scaling of Biometric False Match Rates Using Extreme Value Theory”
- Brian DeCann and Arun Ross, “Modeling an Anonymous Identification System”
- Patrick Grother, “Evaluation of 1:N Recognition Algorithms: IREX III and MBE 2010 Methods + Analysis”
- Srikanth Nadhamuni, “Very Large Scale Multimodal Testing Methods + Results for India's UID System”

A Forward and Upward Trajectory

- Scientific knowledge is not strictly cumulative, but depends on our (us, right here, right now) continuity of interest, clarity of vision and openness to what is possible, necessary, fruitful.
- We pursue dead ends and hot leads with equal gusto
  - Which is which will be left to our future historians
- We don't always remember what we already know
  - History is a great teacher!
- Sometimes it all comes together for lasting progress, but often along competing tracks
- Two areas ready for advancement this week: vulnerability assessment, understanding large-scale performance