Testing Trajectories

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Your Favorite Topic Here

"State of the Art"
Your Favorite Topic Here

Level of Knowledge

TIME ⇒

Requirement

“State of the Art”

“Gap” / “Challenge”

International Biometric Performance Conference  2012

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Your Favorite Topic Here

Level of Knowledge vs. TIME

"State of the Art"

"ROADMAP"

International Biometric Performance Conference 2012
Is Scientific Knowledge Cumulative?

- Contentious issue in the late 20\textsuperscript{th} 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
• 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”


– Ehmer G., Ein Gaunertrick gegen die Daktyloskopie, Arch Kriminal—Anthropol Kriminalistik 1909;200.

– Carlson M., Fingerprint can be forged. Virginia Law Register 1920;5.

Media Interest – 1970s

• “Diamonds are Forever” 1971
Vulnerability Assessment – 1970s

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 commercial 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
- Missing: US National Biometric Test Center
NSA Goes Public with Vulnerability Assessment

CBS “60 Minutes II”, Jan. 24, 2001
Vulnerability Assessment -- 2000s

- Fraunhofer
- CESG

  - Biometric Protection Profiles
    - CESG
    - BSI
    - BMO
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

\[
FN_M_{sys} = \varepsilon_{ensemble} + \left[1 - \varepsilon_{ensemble}\right] \prod_{i=1}^{m} \left[1 - (1 - FN_M_i) \sum_{j=Q-1}^{T-i} (T-i)(1 - FN_M_U)^j (FN_M_U)^{T-i-j}\right]
\]

\[
FN_R_{sys} = 1 - \prod_{i=1}^{m} \left[1 - FN_R_i \sum_{j=Q-1}^{T-i} (T-i)FN_R_U^j (1 - FN_R_U)^{T-i-j}\right]^{N*P_i}
\]
Estimating the Parameters (forgotten)
Estimating the Parameters (remembered)
Finger Variability

RIGHT HAND ROC

LEFT HAND ROC

FALSE NON-MATCH RATE (LOG)

FALSE MATCH RATE (LOG)

MIDDLE
RING
INDEX
THUMB

International Biometric Performance Conference 2012
Penetration Rate Correlations

### TABLE 4: TWO-FINGER BINNING STATISTICS

<table>
<thead>
<tr>
<th>Finger</th>
<th>Error Rate</th>
<th>Error if independent</th>
<th>Penetration Rate</th>
<th>Penetration if independent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thumb</td>
<td>0.005</td>
<td>0.005</td>
<td>0.52</td>
<td>0.30</td>
</tr>
<tr>
<td>Index</td>
<td>0.007</td>
<td>0.007</td>
<td>0.25</td>
<td>0.19</td>
</tr>
<tr>
<td>Middle</td>
<td>0.015</td>
<td>0.019</td>
<td>0.55</td>
<td>0.71</td>
</tr>
<tr>
<td>Ring</td>
<td>0.017</td>
<td>0.017</td>
<td>0.55</td>
<td>0.44</td>
</tr>
</tbody>
</table>

### TABLE 5: MULTIPLE-FINGER BINNING STATISTICS

<table>
<thead>
<tr>
<th>Fingers</th>
<th>Error Rate</th>
<th>Error if independent</th>
<th>Penetration Rate</th>
<th>Penetration if independent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four: Thumb and index</td>
<td>0.012</td>
<td>0.012</td>
<td>0.15</td>
<td>0.059</td>
</tr>
<tr>
<td>Eight: Thumb, index, middle, ring</td>
<td>0.040</td>
<td>0.048</td>
<td>0.08</td>
<td>0.018</td>
</tr>
</tbody>
</table>
Further Reduction

- 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.

\[
f(\bar{x} | \alpha, \beta, \bar{n}) = \int f(\bar{x}, \bar{p} | \alpha, \beta, \bar{n}) dp = \int f(\bar{x} | \bar{p}, \bar{n}) f(\bar{p} | \alpha, \beta) dp
\]

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

- Where there are n individuals tested m times and \( \alpha, \beta \) are parameters of the Beta distribution of p among the individuals.
An Empirical Approach by NIST


• “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:

\[ \text{FMR} = f(\text{binning}) \]
Additional Work


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”
• 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
Submit your research and make your mark in IET Biometrics