Human Biometric Sensor Interaction (HBSI)
Latest Research and Process Model
Thanks to the international team of researchers

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What is the Human Biometric Sensor Interaction Framework?

- It's not usability – that’s defined as the ease of use and learnability of a human-made object (NIST, 150 9241-11:1998)

- It's not ergonomics – that’s the study of people’s efficiency in their working environment

- Previous versions, dated 2003-2015 did attempt to address the intersection of the human and biometric system; however, the most recent version has progressed beyond usability and ergonomics.

- It's beyond usability and ergonomics

- **Today, the HBSI model provides real time situational awareness recommendations and feedback for users interacting with a biometric system**
Our philosophy

Usability and Ergonomics have a role, but:

- Biometric systems are not just a fingerprint sensor or an iris sensor in a stand-alone environment
- Standardized metrics are difficult to define for all situations, whether that be use cases, operational and scenarios
- Today, many biometric deployments are a subset in a system of systems
- Usability models typically look at the role of the genuine user, impostors are difficult to test and evaluate
- **What use is usability analysis if it is not in real-time and actionable?**
The evolution of the model – 13 years of history

<table>
<thead>
<tr>
<th>Year</th>
<th>Hand</th>
<th>Finger</th>
<th>Iris</th>
<th>Face</th>
<th>Dynamic Signature</th>
<th>Voice</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Illumination [2]</td>
<td></td>
<td></td>
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<tr>
<td>2004</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mobile iris</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Gender [20], Skin characteristics [21]</td>
<td></td>
<td></td>
<td></td>
<td>Advances [22]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Hand alignment</td>
<td>Force finger interactions [31], Slap segmentation [32]</td>
<td>HBSI training</td>
<td>Detractors</td>
<td>Signature interaction errors [33], Forgery</td>
<td>Evolution of HBSI [34]</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Iris Recognition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Transaction Times [35], Number of impressions [36]</td>
<td>Mobile eye recognition</td>
<td>On Mobile Devices</td>
<td>Related Voice data collection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Use of Critical and Associated Tracking Points, HBSI Expansion [38], Mobile Biometric Usability Assessment [39]</td>
<td>Interaction evaluation of a mobile voice authentication system [40]</td>
<td></td>
<td>Development of a test harness for biometric data collection and validation [41], A framework for Biometric and Usage Performance Assessment of Automated Border Control Processes [42]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

1. Single modality → Multimodality
2. Changing designs (ergonomics?)
3. Manipulating single variables to improve image quality
4. Mobile devices (scenario and wild – wild difficult to observe)
5. Automatic classification of metrics based on presentation
HBSI Validation

• Work across a number of modalities and mobile biometrics, and the framework is modality agnostic

• We have used this model, not only on how an observer assesses the biometric user in a static environment but we have conducted multiple tests in the wild. We have now collected HBSI metrics on over 1,000 subjects in the mobile space over the last two years

• Over the past 13 years over 3,000 subjects have been processed through the various iterations of the HBSI models that were developed at Purdue University
The evolution of the framework – 13 years of history

<table>
<thead>
<tr>
<th>General Model</th>
<th>Hand, Face, Iris, Fingerprint, Voice, Mobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral</td>
<td>Signature</td>
</tr>
<tr>
<td>False Claim</td>
<td></td>
</tr>
<tr>
<td>Attack</td>
<td></td>
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<tr>
<td>Token</td>
<td></td>
</tr>
<tr>
<td>Process</td>
<td>Attended Border Booth</td>
</tr>
<tr>
<td></td>
<td>Unattended Border Booth</td>
</tr>
</tbody>
</table>
HBSI in an operational / scenario environment

- Scenario

- Model
  - Operator
  - User
  - Environment
  - Baggage
Process HBSI

- Process HBSI model works for a number of different modalities – it is in fact user agnostic in terms of biometrics, or any technology. This could work for bar code scanners, passport readers and the like.
- The process HBSI model works for many scenarios, and was designed because of the processes associated with multi-interactions whether that be on a phone, PC, or in a complex system such as a kiosk.
# HBSI Unattended Kiosk

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Possible Systems Handling</th>
<th>HBSI</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unaware of the process, facing away from the camera</td>
<td>Biometric Presented</td>
<td>Defective Interactions</td>
<td>It is clear in this example that the user made an incorrect presentation</td>
</tr>
<tr>
<td></td>
<td>Not Presented</td>
<td>False Interactions</td>
<td></td>
</tr>
<tr>
<td>User understands where the camera is and is aware of where to look</td>
<td>Biometric Presented</td>
<td>Failure to detect,</td>
<td>In this example it is clear the user make a correct presentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or SPS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biometric not presented</td>
<td>Failure to Process</td>
<td></td>
</tr>
<tr>
<td>User is distracted through interaction and loses focus on looking at the</td>
<td>Biometric Presented</td>
<td>Successfully Processed</td>
<td>Cautious behaviors are difficult to classify as a correct or incorrect behavior.</td>
</tr>
<tr>
<td>camera</td>
<td></td>
<td>Samples, FTP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biometric not presented</td>
<td>DI, CI, FI</td>
<td></td>
</tr>
</tbody>
</table>
Model works for border environments

- Three different classifications of ABC systems (Frontex)
  - One-step process (token + identity + border crossing)
  - Integrated two-steps (token and eligibility, then identify)
  - Segregated two-step process (step 1, then a token or ticket, then step two)

<table>
<thead>
<tr>
<th>Evaluation Points</th>
<th>Definition</th>
<th>Possible Outcome</th>
<th>HBSI categorization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traveler Presence</td>
<td>Is the traveler’s presence detected?</td>
<td>Yes, No (Reject / Assist)</td>
<td>FTD / DI</td>
</tr>
<tr>
<td>Token Presence</td>
<td>Is the token detected?</td>
<td>Yes, No (Reject / Assist)</td>
<td>FTD / DI</td>
</tr>
<tr>
<td>Token Read</td>
<td>Was the token successfully read?</td>
<td>Yes, No (Reject / Assist)</td>
<td>SPS, FTP / CI</td>
</tr>
<tr>
<td>Biometric Capture</td>
<td>What biometric data is required?</td>
<td>Identify Modality</td>
<td>All</td>
</tr>
<tr>
<td>Data Verification</td>
<td>At what point does identification take place?</td>
<td>Database / Local Level</td>
<td>Traditional Biometric metrics</td>
</tr>
</tbody>
</table>
## Building blocks of the HBSI framework

<table>
<thead>
<tr>
<th>Pre Interaction</th>
<th>During Interaction</th>
<th>Post Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictive tools from research studies and prior data collections</td>
<td>HBSI metrics – tested and evaluated on many modalities</td>
<td>Retraining of the system</td>
</tr>
<tr>
<td>Characteristics about the user from other document data - Passport</td>
<td>User behavior – through the use of primary and secondary tracking points</td>
<td>Biometric data from the system (IMQ, Performance)</td>
</tr>
<tr>
<td>Connectors to other 3rd party data</td>
<td>Environmental data (sensor networks and IoT)</td>
<td>Context</td>
</tr>
</tbody>
</table>

**GOAL:** Optimize the system
Adaptive HBSI

- The ability to influence the environment to enable the biometric system to optimally perform for an individual
  - Behavior
  - Context
  - Environment
  - Biometric performance
  - Biometric image quality
HBSI Model has grown beyond usability to increase situational awareness to modify user behaviors or adapt deployment parameters to increase user experience and optimize system performance
HBSI as part of the system

Scenario in the center

- Real time collection of metrics, including body (pose, angle etc.), face expression, environmental (light, noise etc.), sensor actions, and biometric measurements.
- As this is part of a system (not just the biometric), these metrics are standalone, and not a function of the biometric performance.
- Reacting to the metrics will illustrate how the biometric component of the system works.

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Scenario Evaluations – Critical and Associated Tracking

Transaction Luggage Combination
1. Backpack
2. Large Roller
3. Medium Roller
4. Small Duffel
5. Large Duffel
6. Backpack + Large Roller
7. Backpack + Medium Roller
8. Backpack + Small Duffel
9. Backpack + Large Duffel
10. Small Duffel + Large Roller
11. Large Duffel + Large Roller
12. Large Duffel + Small Duffel
13. No Luggage
Border control scenario

- Subject patterns through the booth (estimate metrics such as throughput impacts)
- Global view of HBSI metrics, automatically segmented in real-time
- Intuitive visualization
Detailed information about the subject
Real-time data about individuals within the system

- Distribution of HBSI metrics, can then be tied into the traditional biometric metrics
- Here we see the distribution of iris image quality and iris recognition errors
- We can do this on any number of modalities
HBSI model (Current Work)

- Cloud-based
- Mobile apps developed (iOS, Android, Windows)
- Natural language queries
- Real-time feedback
- Dashboards for actionable data
- Visualization regardless of metric philosophy
Education and Training

- The HBSI model developed at Purdue University has examined the HBSI models, and we have now provided access to our models online.
- The next step we are working on is to demonstrate the usability issues that people face in a mixed reality.
HBSI Mixed Reality using HoloLens

• Visualize from the data from different perspectives (users, operators, integrators)
• Immerse researchers into the flow of the operation to assess the changes in performance of the biometric system (dry runs)
• Alter the environment for testing and evaluation
• Potential for anomaly and behavior detection to support risk and decision sciences
• Training purposes
Border control scenario

- Subject patterns through the booth (estimate metrics such as throughput impacts)
- Global view of HBSI metrics, automatically segmented in real-time
- Intuitive visualization
HBSI: Beyond Usability

Learn more at hbsi.icbrpurdue.org
References


References


References


[38] Expanding the Human-Biometric Sensor Interaction Model to Identity Claim Scenarios , Stephen J. Elliott, Kevin O’Connor, Eric Bartlow, Joshua J. Robertson and Richard M. Guest – IEEE International Conference on Identity, Security and Behavior Analysis (ISBA 2015), Hong Kong, March 2015


[41] Richard Guest · Oscar Miguel Hurtado, Mobile Biometric Usability Assessment within PiDaas, EAB Research Projects Conference (EAB-RPC) 2015, Darmstadt, Germany, 09/2015.


Any Questions

Purdue University – the home of HBSI