Bio- and Cyber-Metrics
Can biometrics be cybermetrics?

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What Biometrics are there?

Omron Corp; Tiresias.org; HR Industries; Fujitsu; Morpho
What is not a biometric?

(identity theft?)
Milestones in Southampton’s Biometrics

80’s face recognition
94 idea on gait
95 first PhDs on gait at ECS
99 first book on biometrics
99 supported by DARPA
00’s started ear
03 first conviction by gait
05 first book on gait
09 first broadcast demo (BBC1)
09 first UK conviction
10 soft biometrics for ID
11 commercialisation of gait
Major points

• Biometrics is **new** (relatively)
• Biometrics can be deployed on a **national** scale
• Biometrics is **personal**
• Biometrics is **not expensive**
• Biometrics has much greater possible **usage**
Where is gait as a biometric?
Does gait biometrics really work?
Performance Evaluation of Vision-based Gait Recognition using a Very Large-scale Gait Database

- From Osaka Univ, Japan
- Gathered large database >1000 subjects, at exhibition

Okumura, Iwama, Makihara, and Yagi, *Proc. BTAS 2010*
Data collection

• In conjunction with demonstration in three exhibitions

<table>
<thead>
<tr>
<th>Exhibition</th>
<th>Term</th>
<th>#Days</th>
<th>#Visitors (approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outreach activity in DIM (Dive Into the Movie) project</td>
<td>March 2009</td>
<td>3</td>
<td>1,600</td>
</tr>
<tr>
<td>5th Regional Disaster and Crime Prevention Expo</td>
<td>June 2010</td>
<td>2</td>
<td>270</td>
</tr>
<tr>
<td>Open campus at Osaka university 2010</td>
<td>Aug 2010</td>
<td>1</td>
<td>70</td>
</tr>
</tbody>
</table>

• Each subject
  – Signed release agreement for research-purpose use
  – Provided gender and age information

Makihara, Okumura, Iwama, and Yagi, Proc. IJCB 2011
Recognition

- Consistent with many other studies
- First gait biometrics paper - Cunado, Nixon and Carter (AVBPA 1997) - had 90% CCR

Okumura, Iwama, Makihara, and Yagi, Proc. BTAS 2010
Gait-based Age Estimation using a Whole-generation Gait Database

• How old is he/she?

<table>
<thead>
<tr>
<th>Subject</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gait</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- A. 4 years old
- B. 14 years old
- C. 24 years old

- A. 62 years old
- B. 72 years old
- C. 82 years old

- A. 24 years old
- B. 34 years old
- C. 44 years old

Makihara, Okumura, Iwama, and Yagi, *Proc. IJCB 2011*
Experiments - Qualitative evaluation

• Typical success and failure modes (male)

Greater than 15 yrs error

<table>
<thead>
<tr>
<th>3</th>
<th>6</th>
<th>9</th>
<th>14</th>
<th>20</th>
<th>24</th>
<th>27</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>(37)</td>
<td>(24)</td>
<td>(20)</td>
<td>(16)</td>
<td>(21)</td>
<td>(37)</td>
<td>(28)</td>
<td>(19)</td>
</tr>
</tbody>
</table>

Within 3 yrs absolute error

<table>
<thead>
<tr>
<th>4</th>
<th>7</th>
<th>10</th>
<th>14</th>
<th>18</th>
<th>22</th>
<th>25</th>
<th>29</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>9</td>
<td>13</td>
<td>17</td>
<td>32</td>
<td>35</td>
<td>38</td>
<td>42</td>
</tr>
</tbody>
</table>

Less than -15 yrs error

<table>
<thead>
<tr>
<th>4</th>
<th>10</th>
<th>14</th>
<th>18</th>
<th>33</th>
<th>37</th>
<th>40</th>
<th>43</th>
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</thead>
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<td>4</td>
<td>7</td>
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<td>14</td>
<td>18</td>
<td>22</td>
<td>25</td>
<td>29</td>
</tr>
</tbody>
</table>

Change of head to body ratio

Smaller arm swing

Stoop & Middle-age spread

Makihara, Okumura, Iwama, and Yagi, Proc. IJCB 2011
Recent Conviction

Bag snatcher case in London 2008, evidence used in identity confirmation in conviction

Guilty, 5 Years, June 2009

Bouchrika, Nixon, Carter, *J. Forensic Science* (2011), and Eusipco 2010
Commercialisation
Other work

- Viewpoint invariance
- Time invariance
- Accelerometer/ phone for recognition
- Gender
- Medicine
- Age
- Pedestrian/ security/ surveillance
US demonstration ......
Soft Biometrics

Our soft biometrics (attributes)

- Use human labels
- Are grounded in psychology
- Use psychology in their generation
- Analyse correlation between human vision and computer vision

Reid, Samangooei, Nixon and Ross, Handbook of Statistics 31, 2013
What can you recognise?
Exploring Human Descriptions

- We explore semantic descriptions of:
  - physical traits
  - semantic terms
  - visible at a distance

![Diagram with traits and terms]

Samangooei and Nixon, SAMT2008
Samangooei, Guo and Nixon, IEEE BTAS 2008
On Semantic Descriptions

Advantages
1. No (feature/ sensor) ageing
2. Available at a distance/ low resolution/ poor quality
3. Fit with human description/ forensics
4. Complement automatically-perceived measures
5. Need for search mechanisms

Disadvantages
1. Psychology/ perception
2. Need for labelling
Traits and Terms

Global Features

- Features mentioned most often in witness statements
- **Sex** and **age** quite simple
- **Ethnicity**
  - Notoriously **unstable**
  - There could be anywhere between 3 and 100 ethnic groups
  - We’ve chosen 3 “main” **subgroups** and 2 extra to match UK Police force groupings

Body Shape

- **Global**
  - Sex
  - Ethnicity
  - Skin Colour
  - Age
- **Body Shape**
  - Figure
  - Weight
  - Muscle Build
  - Height
  - Proportions
  - Shoulder Shape
  - Chest Size
  - Hip size
  - Leg/Arm Length
  - Leg/Arm Thickness

Head

- **Head**
  - Hair Colour
  - Hair Length
  - Facial Hair Colour/Length
  - Neck Length/Thickness
Apologies, we cannot be ... correct
Traits and Terms

Body Features
• Based on whole body description stability analysis by MacLeod et al.
  – Features showing consistency by different viewers looking at the same subjects
• Mostly comprised of 5 point qualitative measures
  – (Very Thin -> Very Fat, Very Short-> Very Long)
• Most likely candidate for association with gait

- Global
  - Sex
  - Ethnicity
  - Skin Colour
  - Age

- Body Shape
  - Figure
  - Weight
  - Muscle Build
  - Height
  - Proportions
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  - Leg/Arm Length
  - Leg/Arm Thickness

- Head
  - Hair Colour
  - Hair Length
  - Facial Hair Colour/Length
  - Neck Length/Thickness
Traits and Terms

Head Features
• Mentioned **consistently** by people even at **long distances**
• Prominent area of **gaze**
• **Hair Length** and **colour** inherently connected with style
  – Many different hair **styles**
  – Style **avoided** due to unfamiliarity of annotators

• **Global**
  – Sex
  – Ethnicity
  – Skin Colour
  – Age
• **Body Shape**
  – Figure
  – Weight
  – Muscle Build
  – Height
  – Proportions
  – Shoulder Shape
  – Chest Size
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• **Head**
  – Hair Colour
  – Hair Length
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  – Neck Length/Thickness
Annotation Interface

Web interface constructed to gather annotations against any source

Designed to deal with issues of human description/perception

**Memory issues**: view a subject as many times as required

**Defaulting**: explicitly asked to fill out every feature

**Value Judgments**: categorical qualitative values.

**Observer variables**: collect description of annotators
Adding semantic labels

Subjects:
- Self: Done
- 1: Done
- 2: Done
- 3: Done
- 4: Done
- 5: Done
- 6: Done
- 7: Done
- 8: Done
- 9: Done
- 10: Done
- 11: Done

Click Save when you're done annotating and have reached the bottom of the list below.

Global
Sex: Male
Age: Middle Aged
Ethnicity: European
Skin Colour: Tanned

Head
Hair Colour: Grey
Hair Length: Short
Facial Hair Length: 
Facial Hair Colour: 

help
Biometrics: recognition capability

Samangooei and Nixon, IEEE BTAS 2008
Biometrics: retrieval by labels

Query: Male

Query: Pre-adolescent

Samangooei and Nixon, SAMT 2008
Successful Results

- **Hair Length** (Long vs Short)
Successful Results

- Age (Pre-Adolescent vs Young Adult)
Problems with absolute descriptors

- Subjective = unreliable
- Categorical = lacks detail

Reid and Nixon, IEEE IJCB 2011
Comparative Human Descriptions

- **Objective** categorical labels
- Infer continuous **relative** measurements

Reid and Nixon, *IEEE IJCB 2011*
Ranking Comparative Descriptions

- Use **ELO rating system** from chess to infer relative descriptions
- Turn comparative into a ranked list
- **Alternatives?**
- How **many**?

Reid and Nixon, *IEEE IJCB 2011*
Height correlation (with time)

- Continued suspect exposure
- Limited suspect exposure

Reid and Nixon, IEEE ICDP 2011
Recognition

Retrieval Accuracy

Rank

Relative Measurements
inferred from 10 comparisons
Categorical Labels

Reid and Nixon,
IEEE ICDP 2011
Recognition/retrieval

Incorrect with 10 comparisons

Correct with 1 comparisons

Reid and Nixon, IEEE ICDP 2011
Ear biometrics

Person identification from ear image
Uniqueness: used in **forensics**
Unique advantage: **age invariant**
Unique disadvantage: **hair**!
Much **smaller** field than gait recognition

BBC1, 2005
Examples....
Model Based Enrolment

Arbab-Zavar and Nixon, ISVC 2007
Model Based Analysis

Extraction by SIFT

Part of the training set

Arbab-Zavar and Nixon, BTAS 2007
Conclusions (and where does this take us?)

• We can make security personal
• Does the UK have this capability?
• Does the UK trust this technology?
• Does this technology work?
• Are we unique?
• Can biometrics be cybermetrics?

..........................questions?
Thanks to the my team and our sponsors

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Some papers (eprints.soton.ac.uk)

- Matthews, T., Nixon M. S., and Niranjan, M., Enriching Texture Analysis with Semantic Data, *IEEE CVPR 2013*