State of the Art in Iris Recognition

Professor Kevin W. Bowyer
This talk is from an academic researcher’s point of view.
This talk is not a broad survey. For that, see:

A Historical Perspective

Iris and Biometric in Advanced Search in IEEE Xplore

- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
A Historical Perspective

1987 – Flom & Safir patent granted;
Worth (re-)reading for various insights.
A Historical Perspective

Iris and Biometric in Advanced Search in IEEE Xplore

1994 – Daugman patent granted
A Historical Perspective

Iris and Biometric in Advanced Search in IEEE Xplore

1995 – IriScan, Oki commercial systems
A Historical Perspective

Iris and Biometric in Advanced Search in IEEE Xplore

1999 – Wildes @ Sarnoff wins Fink Prize
A Historical Perspective

Iris and Biometric in Advanced Search in IEEE Xplore

2003 – UAE border control system begins
A Historical Perspective

2005 – “Iris On the Move” from Sarnoff
A Historical Perspective

Iris and Biometric in Advanced Search in IEEE Xplore

2005 – Flom & Safir patent expires
A Historical Perspective

2005, 2006 – NIST Iris Challenge Evaluations

Iris and Biometric in Advanced Search in IEEE Xplore
2009 – India’s AADHAAR begins
A Historical Perspective

Iris and Biometric in Advanced Search in IEEE Xplore

2011 – Daugman patent expires
A Historical Perspective

2012 – India’s AADHAAR hits 200M enrolled
A Historical Perspective

The field is only about 20 years old.

It has 10 years experience with UAE.

It has 200M enrollees in Aadhaar.

Technologically rich and fast-adapting research and development.
A Historical Perspective

Table 1. Market volume of biometric technology, 2009-2014.
(Source: IBG, Biometrics Market and Industry Report 2009-2014)

<table>
<thead>
<tr>
<th>Source</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingerprint</td>
<td>971.0</td>
<td>1,380.0</td>
<td>1,740.1</td>
<td>2,064.1</td>
<td>2,422.9</td>
<td>2,827.2</td>
</tr>
<tr>
<td>AFIS/live scan</td>
<td>1,309.1</td>
<td>1,489.9</td>
<td>1,816.5</td>
<td>2,064.1</td>
<td>2,422.9</td>
<td>2,965.8</td>
</tr>
<tr>
<td>Iris</td>
<td>174.4</td>
<td>287.8</td>
<td>360.8</td>
<td>480.5</td>
<td>578.3</td>
<td>730.3</td>
</tr>
<tr>
<td>Hand geometry</td>
<td>62.0</td>
<td>62.8</td>
<td>63.7</td>
<td>68.2</td>
<td>76.0</td>
<td>85.0</td>
</tr>
<tr>
<td>Middleware</td>
<td>275.0</td>
<td>327.7</td>
<td>413.8</td>
<td>525.2</td>
<td>625.2</td>
<td>732.6</td>
</tr>
<tr>
<td>Face</td>
<td>390.0</td>
<td>510.8</td>
<td>675.4</td>
<td>848.5</td>
<td>1,097.3</td>
<td>1,417.8</td>
</tr>
<tr>
<td>Voice</td>
<td>103.8</td>
<td>109.3</td>
<td>113.5</td>
<td>136.3</td>
<td>167.5</td>
<td>189.7</td>
</tr>
<tr>
<td>Vascular</td>
<td>83.0</td>
<td>102.1</td>
<td>132.2</td>
<td>172.2</td>
<td>199.5</td>
<td>235.7</td>
</tr>
<tr>
<td>Others</td>
<td>54.0</td>
<td>85.6</td>
<td>107.5</td>
<td>131.8</td>
<td>154.2</td>
<td>184.9</td>
</tr>
<tr>
<td>Total</td>
<td>$3,422.3</td>
<td>$4,356.9</td>
<td>$5,423.6</td>
<td>$6,581.2</td>
<td>$7,846.7</td>
<td>$9,368.9</td>
</tr>
</tbody>
</table>

What Comes Next?

How can we think about what changes we should expect to see in iris recognition in the future?
### What Comes Next?

<table>
<thead>
<tr>
<th></th>
<th>Things You Can Do</th>
<th>Things You Can’t Do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Things You Know</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Things You Don’t</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### What Comes Next?

<table>
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<th>Things You Know</th>
<th>Things You Can Do</th>
<th>Things You Can’t Do</th>
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</thead>
<tbody>
<tr>
<td>Things You Can Do</td>
<td>engineering incremental advances</td>
<td></td>
</tr>
<tr>
<td>Things You Don’t</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Continuous incremental advances in all aspects of iris recognition through solid engineering.

Many people may develop similar versions of these advances at about the same time.
You Know You Can Do

- More flexible acquisition
  - At a distance, on the move, ...
  
  (some amazing stuff in IARPA BEST)
You Know You Can Do

- More flexible acquisition
- Improved segmentation
  - Eyelashes, specular highlights, …
You Know You Can Do

Eyelash occlusion of iris texture.
You Know You Can Do

Specularities on iris texture.
You Know You Can Do

- More flexible acquisition
- Improved segmentation
- Multi-biometrics
  - Face + iris
  - Ocular + iris
  - Multiple iris templates, possibly for varying dilation, etc
Apologies to Arun Ross for scooping him on a video of new hi-security multibiometrics.
You Know You Can Do

- More flexible acquisition
- Improved segmentation
- Multi-biometrics
- Cancelable / revocable
## What Comes Next?

<table>
<thead>
<tr>
<th>Things You Know</th>
<th>Things You Can Do</th>
<th>Things You Can’t Do</th>
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<tr>
<td>Things You Don’t</td>
<td>surprise opportunities</td>
<td></td>
</tr>
</tbody>
</table>
Recent examples of this type of advance include finding similarity in iris texture where the “theory” suggested there was none.
Although eye color is of course strongly determined genetically, as is overall iris appearance, the detailed patterns of genetically identical irises appear to be as uncorrelated as they are among unrelated eyes.

Don’t Know You Can Do

- Prediction of subject ethnicity
- Prediction of subject gender
- Similarity of left and right iris

Someone will find utility in such “new” abilities.
## What Comes Next?

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<tr>
<td></td>
<td>surprise</td>
<td>weaknesses</td>
</tr>
</tbody>
</table>

**Things You Know**

**Things You Can Do**

**Things You Can’t Do**
A recent example is pupil dilation. It was once believed that varying pupil dilation did not affect accuracy of iris recognition, that dilation differences were handled by “rubber sheet” model.
Although the iris stretches and contracts ... Such distortions in the texture can readily be reversed mathematically ... to extract and encode an iris signature that remains the same over a wide range of dilations.

1994 Daugman patent
Studies by Notre Dame and by NIST showed that varying pupil dilation degrades matching accuracy.

Solutions were proposed immediately.

Antwan Clark’s talk later this morning deals with building a “first principles” math model for dilation changes.
### What Comes Next?

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<td></td>
<td>fundamental limits from theory</td>
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</table>
“Truths” that establish boundaries on what it is reasonable to try to do.

An example might be that you can’t usefully image the natural iris texture through a cosmetic contact lens.
Know You Can’t Do
We should expect:

- Continuous improvement of abilities of “normal” iris recognition
- New capabilities from exploiting newly discovered abilities
- Rapid patching of occasional newly revealed limitations
Questions ?