CSE 40537 / 60537: Biometrics

Iris Recognition 5
Open Research Questions

• Can the presence of contact lenses be automatically detected?

• Can the artifacts created by clear contact lenses be reversed or at least masked out?
Iris Template Aging
What is template aging?

“Longer time intervals generally make it more difficult to match samples to templates due to the phenomenon known as ‘template aging’.”

ISO/IEC 19795-1:2006 "Information technology - Biometric performance testing and reporting -...", Section 6.4.6.
What is template aging?

“This refers to the increase in error rates caused by time-related changes in the biometric pattern, its presentation and the sensor.”

ISO/IEC 19795-1:2006 "Information technology - Biometric performance testing and reporting -...", Section 6.4.6.
Flom and Safir revisited

The 1987 patent allows for the possibility that re-enrollment might be needed to maintain performance.
Flom and Safir revisited

“...the significant features of the iris remain extremely stable and do not change over a period of many years.”

“Even features which do develop over time... usually develop rather slowly, so that an updated iris image will permit ID for a substantial period...”

1984

2002

Flom & Safir, U.S. Patent #4,641,349, 1987
Daugman’s Patent

An opposing viewpoint:

The iris of every human eye has a unique texture of high complexity, which proves to be essentially immutable over a person's life.

Which narrative won?

The “essentially immutable over a person’s life” view took over, and gave rise to the idea that “a single enrollment can last a lifetime”.

Artifacts from the literature

“...the iris is highly stable over a person’s lifetime...”


“A key advantage... is... template longevity, as, barring trauma, a single enrollment can last a lifetime.”

Iris Recognition, Wikipedia, March 17, 2011.
What does medicine tell us?

From medical literature of the same time (1994), we know that the iris changes functionally with increased age.
Observable aging effect

Observable aging effect

“Pupil size decreased linearly as a function of age at all illuminance levels. ... The rate of change of pupil diameter with age decreased from 0.043 mm per year at the lowest illuminance level to 0.015 mm per year at the highest. ..."

One biologically and physically plausible change

- Smaller average pupil size with age
- Greater time lapse translates into greater average difference in dilation
- Greater difference in dilation degrades iris match scores

March 2008  March 2011
The shape of the cornea

"With the rule" astigmatism

Typical age

Young

Axis of correcting plus cylinder (± 20°)

Axis of correcting minus cylinder (± 20°)

"Against the rule" astigmatism

Old
Experimental Materials & Method

- 43 subjects, 86 irises
- LG 4000 iris sensor
- Two year time lapse, 2008-2010
- 1830 images
- 9K short-term matches, 5 to 51 days
- 10K long-term matches, about 2 years
- Two matchers: IrisBEE, VeriEye
Experimental Results #1

- IrisBEE authentic distribution is clearly degraded
- Impostor distribution seems unchanged
Experimental Results #2

VeriEye authentic distribution is also clearly degraded (larger is better with VeriEye)
Considering the individual irises

- 84 of 86 had an increased IrisBEE mean FHD with longer time lapse
- 82 of 86 had a decreased VeryEye mean score
With about a two-year time-lapse

- IrisBEE: 157% to 305% increase in FRR at thresholds of 0.28 to 0.34
- VeriEye: 239% to 370% increase in FRR at thresholds of 60 to 120
“...the fine texture remains remarkably stable over many decades. Some iris identifications have succeeded over a period of about 30 years.”

(Wikipedia, Iris Recognition, June 11, 2012)

But what is implausible about this claim?
Iris template aging is controversial

In 2013, NIST released the IREX VI report, which appears to find near zero “iris aging” on a large “operational” dataset.
IREX VI vs. Other Datasets

- ISO-IEC 19795-1 compliant dataset
- With NM results
- Dilation naturally occurs

- Not compliant
- No NM results in data
- Dilation in regression

<table>
<thead>
<tr>
<th>Tome-Gonzales, 2008</th>
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<tbody>
<tr>
<td>Baker, 2009</td>
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<td>Fairhurst, 2011</td>
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<td>Czajka, 2013</td>
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<td>Ellavarason, 2013</td>
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IREX VI, 2013
IREX VI Uses...

• A non-standard definition of iris template aging (p. 8-9)

• A dataset, OPSXING, with all images and all non-match results discarded (p. 17)

• An unusual, non-operational regression analysis model (p. 27-28)

(page numbers in July 24, 2013 version of IREX VI report.)
A non-standard definition

“iris aging - irreversible changes to the healthy iris or neighboring anatomy that yield mated dissimilarity scores that increase monotonically with time-separation of the compared images... Reversible changes include dilation...” (p. 9)
A non-standard definition
IREX VI’s “OPSXING” Dataset

• The operational application discards all images; there are no images to look at to “audit” any result
• The operational application discards all above-threshold results; the threshold was adjusted over time; IREX VI truncates HD > 0.27
IREX VI’s “OPSXING” Dataset

IREX VI investigates the change in FNMR over time using a dataset that has all FNM results edited out of it!
IREX VI’s “OPSXING” Dataset

• How much data is missing in IREX VI due to truncating the OPSXING authentic distribution at HD = 0.27?

• We can’t know with certainty, of course, but an educated guess is possible
IREX VI’s “OPSXING” Dataset

- OPSXING enrollment was done with LG 2200 and Panasonic BM-ET 330
- Recognition was done with BM-ET 330
- The ITIIRT report tabulates results for LG 3000 and Panasonic BM-ET 300
Independent test by the International Biometrics Group

<table>
<thead>
<tr>
<th>Cross-Visit Enrollment at Declining HDs</th>
<th>Cross-Visit Enrollment Comparisons</th>
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<tr>
<td></td>
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<tr>
<td></td>
<td>0.330 HD</td>
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Implications for the NIST OPSXING evaluation

- Same-sensor authentic data was probably truncated by about 5% and the cross-sensor authentic data by about 14%
- Suggests that some real caution is needed when using OPSXING data
Non-operational model?

\[ d_{ij} = \beta_1 + \beta_2 T_{ij} + \beta_3 \Delta D_{ij} + \beta_4 \Delta D_{ij}^2 + \beta_5 D_{ij} + \beta_6 D_{ij}^2 + \beta_7 c(r) + b_{i1} + b_{i2} T_{ij} + b_{i3} \Delta D_{ij} + b_{i4} D_{ij} + b_{i5} D_{ij}^2 + e_{ij} \]

- Eye-specific terms
- (Dilation of probe)\(^2\)
- Dilation of probe
- (Dilation difference)\(^2\)
- Dilation difference
- Time lapse
Non-operational model?

• How does the coefficient for time ($\beta_2$) change as more independent variables are added to regression?
• The regression model implies that pupil dilation should be controlled at acquisition – Is this practical? Is the result applicable to other scenarios?
Suggestions to Improve IREX VI

- Use a dataset where the images and the non-match results weren’t thrown away
- Show the dilation-as-function-of-age plot
- Show the authentic distributions for short and long time lapse
- Show results for the simpler, operational regression model as well
- Explain operational implications: active sensor control of dilation assumed?
Open Research Questions

• Does template aging occur?
• Does the rate of template aging vary with demographic factors?
• Can aging-resistant algorithms be designed?