

Biometric Template Aging



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Outline



- **Review of Assignment Results**
- **Template Aging – What is it?**
- **Template Aging – Face**
- **Template Aging – Fingerprint**
- **Template Aging – Iris**
- **Conclusions & Future Research**

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Template Aging



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

A.J. Mansfield and J.L. Wayman, Best Practices in Testing and Reporting Performance of Biometric Devices, Ver 2.01, Aug 2002

Template Aging



Template ageing refers to the increase in error rates caused by time related changes in the biometric pattern, its presentation, and the sensor.

A.J. Mansfield and J.L. Wayman, Best Practices in Testing and Reporting Performance of Biometric Devices, Ver 2.01, Aug 2002

Template Aging



The *template* is the representation of the biometric sample stored as part of an enrollment in the system.

It is not the image of the fingerprint, face or iris, but the set of minutiae point locations, the vector in face space, the iris code, or other “template”.

Template Aging



***Template aging* occurs when matching accuracy degrades with increasing time since enrollment.**

In principle, the authentic and / or the impostor distributions could change.

In practice, it is typically the authentic distribution that changes, resulting in an increased False Reject Rate.

Template Aging



For iris biometrics specifically –

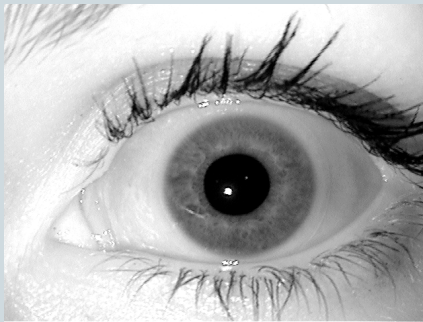
If the iris code computed for the iris texture pattern is for any reason less consistent for images of the same eye taken with longer time between them, this increases the False Reject Rate.

This is “template aging”.

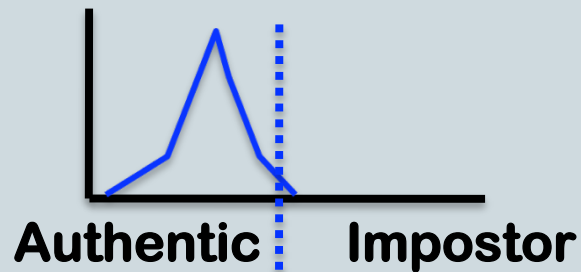
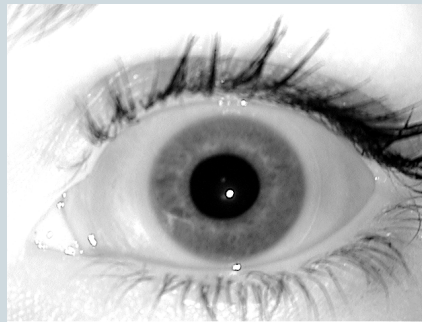
Template Aging



Enrollment



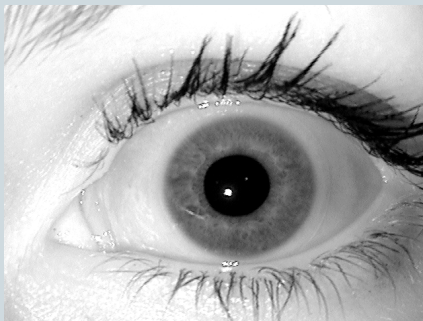
+2 months



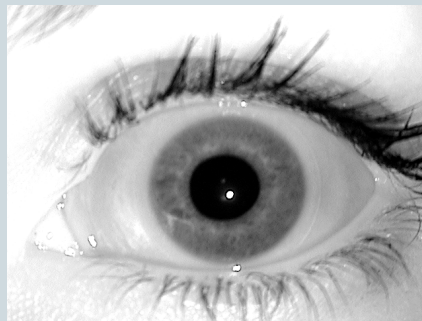
Template Aging



Enrollment



+2 months



+2 years

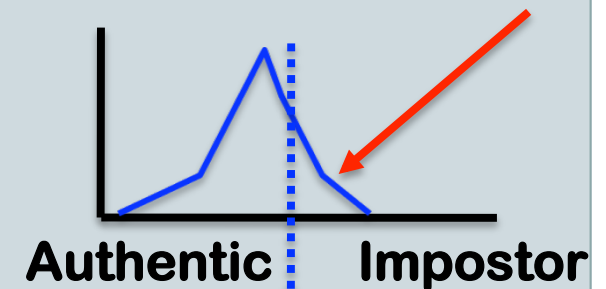
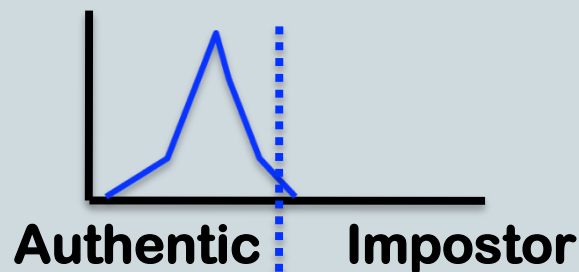


Illustration of template aging as change in the authentic distribution, causing **increased FRR.**

Template Aging



It is tempting to think of template aging is related (only) to biological aging.

But sensor aging, algorithm updates, subject behavior, changes in place or process of acquisition, ... could in principle change the authentic distribution and so also the FRR.

Template Aging



Related terms:

Template selection: Given a set of samples for possible enrollment, which one(s) to use?

Template update: Given one or more probe samples, when and how to update the enrollment sample(s)?

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Template Aging – Face



It seems that more is known about template aging in face than in iris or fingerprint: FERET, FRVT, papers at each BTAS, one or two surveys, ...

Still, it is a hot topic of current research and there is much that is not known.

Template Aging – Face



The FERET report gives a mid 1990s data point on template aging for face. At this time, “partially automatic” was still relevant, and large standard data sets were just getting started.

The FERET Evaluation Methodology for Face Recognition Algorithms, P.J. Phillips et al, *IEEE Trans PAMI* 22 (10), Oct 2000, 1090-1104

Template Aging – Face



The relevant FERET experiment:

“Dup I”

- **1,196 gallery images, one per person**
- **722 probes, closed universe**

“Dup II”

- **864 gallery images; subset of 1,196**
- **234 probes; > 1 year time lapse**

Template Aging – Face



The relevant FERET experiment:

- **“Dup I” – the best rank-1 recognition was just under 60%**
- **“Dup II” – the best rank-1 recognition was about 53%**

So about a year’s time lapse caused about a 7% decrease in rank-one recognition rate.

Template Aging – Face



The FRVT 2002 report gives an early 2000s data point on face template aging.

“Partially automatic” no longer relevant.

Insights on template aging and variation of performance with subject age.

Face Recognition Vendor Test 2002: Overview and Summary, P.J. Phillips et al, March 2003.

Template Aging – Face



The best systems were achieving 90% verification at 1% False Accept Rate on not-same-session image sets.

Average verification rate of top three systems ranged from about 80% for 0-60 day time lapse, to 55+ for 1080-1140 day time lapse, on images of 37K+ persons.

Template Aging – Face



A very important question for real-world applications is the rate of decrease in performance as time increases between the acquisition of the database of images and new images presented to a system. FRVT 2002 found that for the top systems, performance degraded at approximately 5% points per year.

Template Aging – Face



... recognition rates for older people were higher than younger people. For 18 to 22 year olds the average identification rate for the top systems was 62%, and for 38 to 42 year olds was 74%. For every ten years increase in age, on average performance increases approximately 5% through age 63.

Template Aging – Face



The “MBE Still Evaluation” gives a late 2000) data point.

One dataset used is “LEO”, law enforcement booking images from 1960s to 2008, almost 2M persons, 250K having 2 images.

Report on the Evaluation of 2D Still-Image Face Recognition Algorithms, P. Grother et al, NIST Report #7709, June 2010.

Template Aging – Face



Conclusions: For most verification algorithms, false non-match rates increase by roughly a factor of two over the eight years ... However, one algorithm does exhibit greater resistance to elapsed time. This is unlikely to be a random effect, but ...a more detailed statistical analysis is warranted.

Template Aging – Face



The size of the template aging effect for face has been estimated in various studies from the 1990s until now.

It appears that face recog algorithms have improved at handling aging; the NEC algorithm tested in the MBE may be particularly good.

Template Aging – Face



Physical face aging is all too obvious:

- **Wrinkles**
 - **Sagging**
 - **Skin spots**
 - **Exaggeration of features**
 - **Underlying bone, muscle, etc changes**
- (See papers by Karl Ricanek's group.)**

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Template Aging – Fingerprint



There seems to be very little literature on template aging for fingerprint – I found no reference giving any estimate of the rate of aging. One reference that talks about it but does not estimate it:

Biometric template selection and update: a case study in fingerprints, Uludag, Ross & Jain, *Pattern Recognition* 37, 2004, 1533-1542.

Template Aging – Fingerprint



... the biometric data acquired from an individual is susceptible to changes due to improper interaction with the sensor (e.g., partial fingerprints, change in pose during face-image acquisition), modifications in sensor characteristics (e.g., optical vs. solid-state fingerprint sensor),

Template Aging – Fingerprint



variations in environmental factors (e.g., dry weather resulting in faint fingerprints) and temporary alterations in the biometric trait itself (e.g., cuts/scars on fingerprints).

Uludag et al, *Pattern Recognition* 37, 2004.

Template Aging – Fingerprint



Physical aging of finger / fingerprint:

- **Decreased suppleness of skin**
- **Accumulated cuts, scars, etc.**
- **Wrinkles**
- **Decreased flexibility of joints**
- **...**

Iris Template Aging



... 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 ...*

Flom & Safir patent, 1987

Iris Template Aging



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

Daugman patent, 1994

Iris Template Aging



... the iris is highly stable over a person's lifetime ...

DCT-Based Iris Recognition, D. Monro et al, *IEEE Trans. PAMI* 29 (4), April 2007.

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

Iris Recognition, Wikipedia, March 17, 2011.

Iris Template Aging



The assessment in Flom and Safir, that re-enrollment might possibly be needed, morphed into the marketing myth of “a single enrollment can last a lifetime” – even in the total absence of any study on iris template aging.

Iris Template Aging



Two studies:

- **Initial study: 13 subjects followed over four years using LG 2200 (Baker et al, *ICB 2009*)**
- **Larger study: 43 subjects followed over two years using LG 4000, (Fenker and Bowyer, *WACV 2011*)**

Iris Template Aging



Experimental Materials & Method:

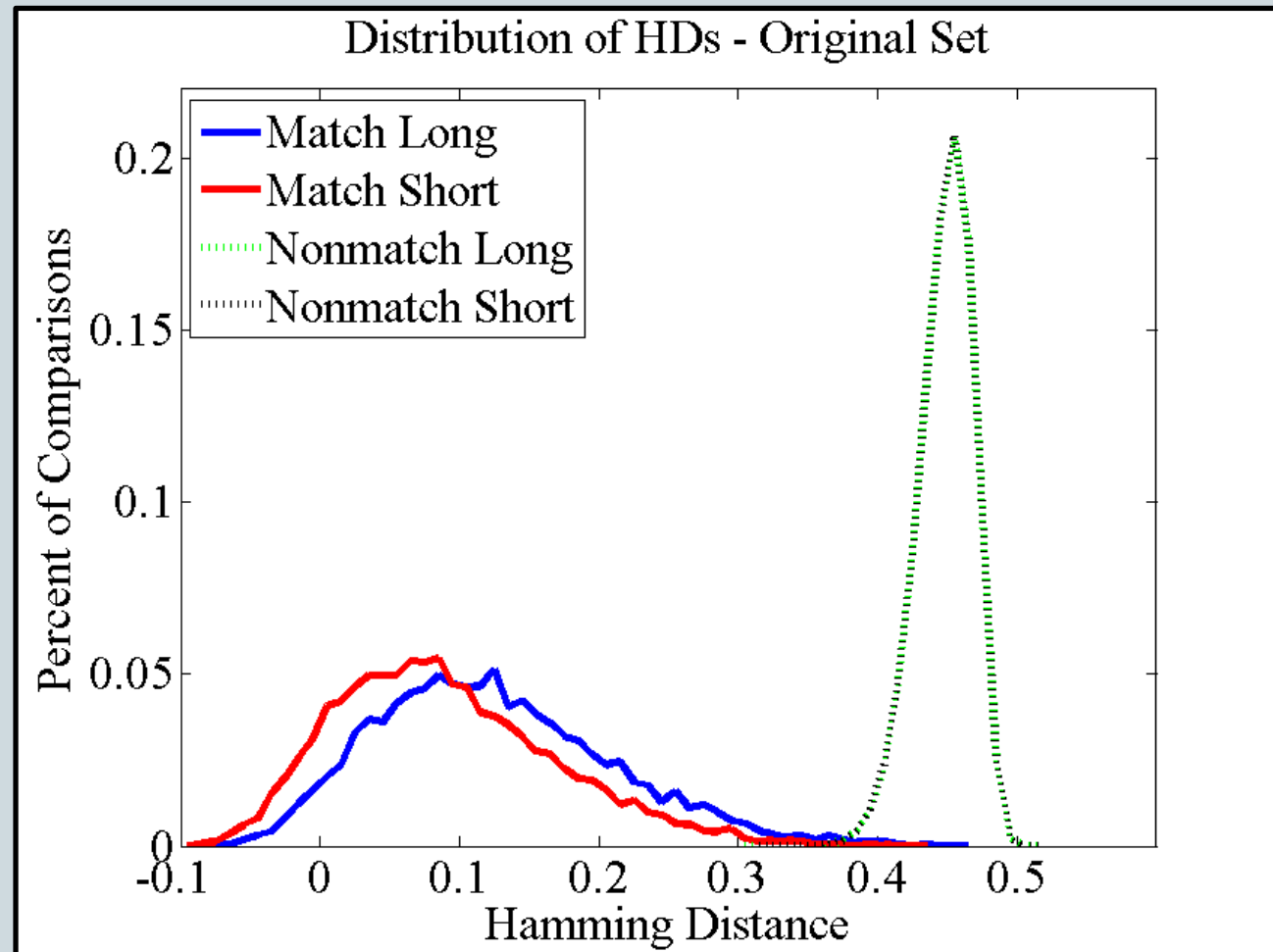
- **43 subjects, 86 irises**
- **LG 4000 iris camera**
- **two years time lapse in 2008-2010**
- **1830 images**
- **9k short-term matches, 5 to 51 days**
- **10K long-term, about 2 years**
- **Two matchers: IrisBEE, VeriEye**

Iris Template Aging



**IrisBEE
authentic
distribution
is clearly
degraded.**

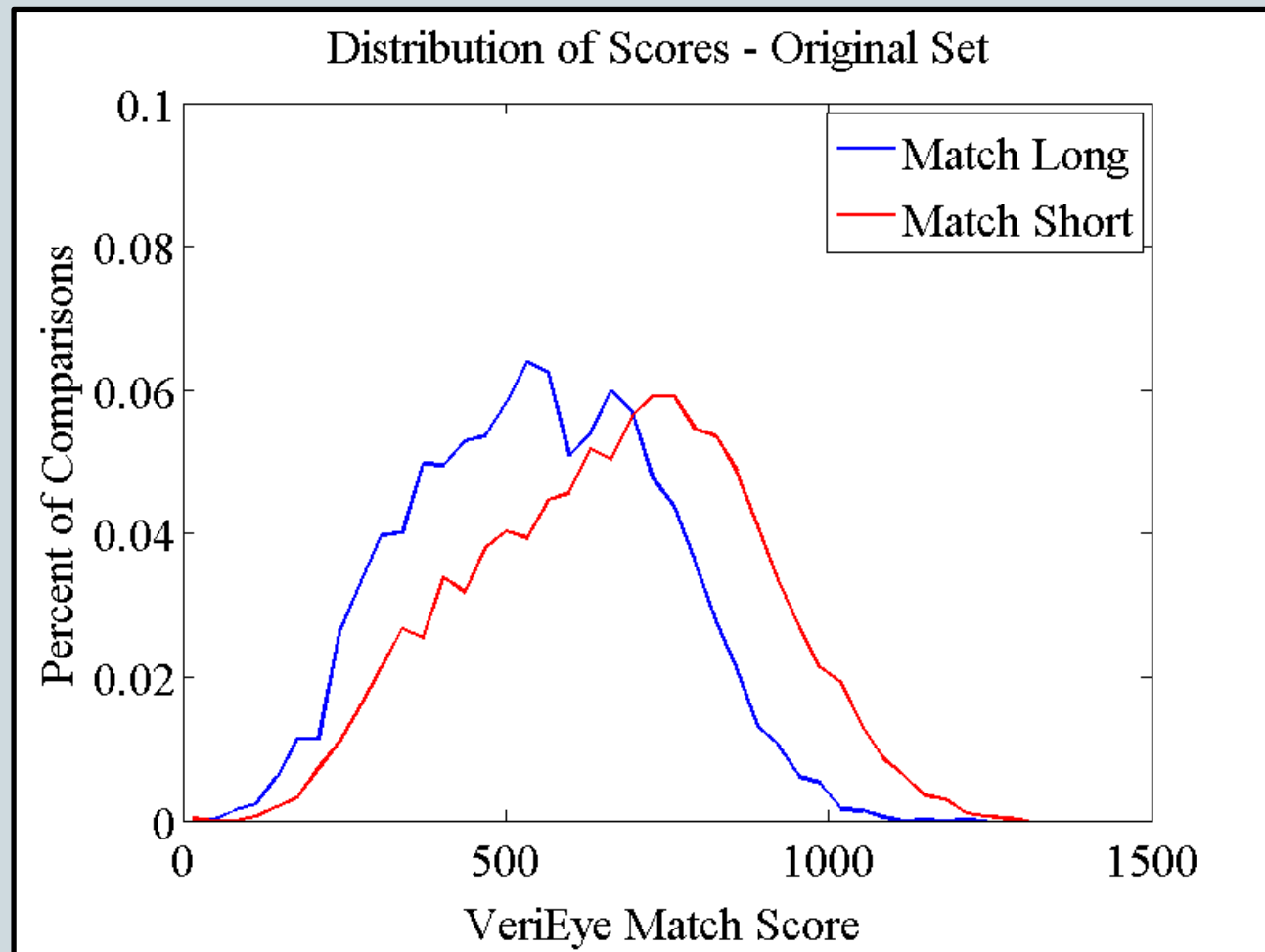
**Impostor
distribution
seems
unchanged.**



Iris Template Aging



**VeriEye
authentic
distribution
is also
clearly
degraded.
(larger is
better with
VeriEye)**



Iris Template Aging



Considering the individual irises:

- **84 of 86 had an increased IrisBEE mean FHD with longer time lapse,**
- **82 of 86 had a decreased VeriEye mean score.**

Iris Template Aging



With about two years time lapse:

For IrisBEE, we find 157% to 305% increase in FRR at thresholds of 0.28 to 0.34.

For VeriEye, we find 239% to 370% increase in FRR at thresholds of 60 to 120.

Iris Template Aging



We know of no study that presents evidence for stability of the iris biometric template over time.

Two different studies (times, subjects, sensors, ...) have found measurable template aging on the time scale of 2 to 4 years.

Template Aging



Template aging has been most studied in the context of face recognition, and algorithms seem to be improving on this dimension.

Less studied for iris biometrics.

Even less studied for fingerprint.



Questions ?