Iris Recognition

Following the work of
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## Biometrics

<table>
<thead>
<tr>
<th>Feature</th>
<th>Fingerprint</th>
<th>Face</th>
<th>Iris</th>
<th>DNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convenience in capturing</td>
<td>fair</td>
<td>good</td>
<td>good</td>
<td>poor</td>
</tr>
<tr>
<td>Low intra-class variance</td>
<td>good</td>
<td>fair</td>
<td>excellent</td>
<td>excellent</td>
</tr>
<tr>
<td>High interclass variance</td>
<td>good</td>
<td>good</td>
<td>excellent</td>
<td>excellent</td>
</tr>
<tr>
<td>Difficult to fool</td>
<td>good</td>
<td>good</td>
<td>excellent</td>
<td>excellent</td>
</tr>
<tr>
<td>Cost effective</td>
<td>fair</td>
<td>good</td>
<td>fair</td>
<td>poor</td>
</tr>
</tbody>
</table>
Properties of the iris

- Has highly distinguishing texture
- Right eye differs from left eye
- Twins have different iris texture
- Not trivial to capture quality image
- + Works well with cooperative subjects
- + Used in many airports in the world
Represent iris texture as a binary vector of 2048 bits

Representation of iris and also of a person

Textured region is unique for a person
Find (nearly circular) iris and create 8 bands or zones

Need to locate the overall region of the iris. Then need to “measure” texture in 1024 small neighborhoods; perhaps 128 around each of 8 bands.
Cross correlate 1024 local areas with a Gabor wavelet.

Get 2 bits at each location/orientation. Threshold the dot product of 2 filters with the iris area.

Polar coordinates locate the texture patch.

Filter (mask) has 2 width parameters.
Use 2\textsuperscript{nd} directional derivative and 1\textsuperscript{st} directional derivative.

Phase-Quadrant Iris Demodulation Code

LOG wave in alpha direction

1\textsuperscript{st} derivative in beta direction
The directional filters defined mathematically

**Setting the Bits in an IrisCode**

\[
\begin{align*}
    h_{Re} &= 1 \text{ if } \Re \int_\rho \int_\phi e^{-i\omega(\theta_0-\phi)}e^{-(r_0-\rho)^2/\alpha^2}e^{-(\theta_0-\phi)^2/\beta^2} I(\rho, \phi) \rho d\rho d\phi \\
    h_{Re} &= 0 \text{ if } \Re \int_\rho \int_\phi e^{-i\omega(\theta_0-\phi)}e^{-(r_0-\rho)^2/\alpha^2}e^{-(\theta_0-\phi)^2/\beta^2} I(\rho, \phi) \rho d\rho d\phi < 0 \\
    h_{Im} &= 1 \text{ if } \Im \int_\rho \int_\phi e^{-i\omega(\theta_0-\phi)}e^{-(r_0-\rho)^2/\alpha^2}e^{-(\theta_0-\phi)^2/\beta^2} I(\rho, \phi) \rho d\rho d\phi \\
    h_{Im} &= 0 \text{ if } \Im \int_\rho \int_\phi e^{-i\omega(\theta_0-\phi)}e^{-(r_0-\rho)^2/\alpha^2}e^{-(\theta_0-\phi)^2/\beta^2} I(\rho, \phi) \rho d\rho d\phi < 0
\end{align*}
\]

sinusoid taper down in radial direction Taper down in tangential direction Image intensity in polar coords
Summary of feature extraction

- Obtain quality image of certain (left) eye
- Find boundary of pupil and outside of iris
- Normalize radii to range, say, 0.5 to 1.0
- Define the 8 bands by radii ranges
- Perform 2 dot products at each of 1024 locations defined around the bands by radius rho and angle phi
How is the matching done to templates of enrolled persons?

- Person scanned under controlled environment and iris pattern is stored with ID (say address, SS#, etc.)
- Might be several million such templates for frequent flyers (6B for all world)
- At airport or ATM, scan unknown person’s left eye; then compute Hamming distance to ALL templates.
Distributions of true matches versus non matches

Hamming distances of true matches

Hamming distances of false matches

DECISION ENVIRONMENT FOR IRIS RECOGNITION

222,743 comparisons of different iris pairs
340 comparisons of same iris pairs

mean = 0.089
stnd dev = 0.042

mean = 0.456
stnd dev = 0.018

d' = 11.36

Theoretical curves: binomial family
Theoretical cross-over point: HD = 0.342
Theoretical cross-over rate: 1 in 1.2 million

Hamming Distance

Count

0 20 40 60 80 100 120

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

0 2000 4000 6000 8000 10000 12000 14000 16000 18000 20000
Active Iris Systems

WFOV denotes "Wide Field Of View"

NFOV denotes "Near Field Of View"
Recognition by comparing unknown scan to MILLIONS of stored templates

- Less than 32% unmatched bits means “MATCH”
- Only need to count unmatched bits – use exclusive OR with machine words
- Mask off bad patches due to eyelid or eyelash interference (have to detect that)