Iris as a Forensic Modality: The Path Forward

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Anatomy of the Iris

- Contraction Furrows
- Pupillary Zone
- Pupillary Boundary
- Crypt
- Collarette
- Limbus boundary
- Ciliary Zone
Automatic Iris Encoding

Segmentation → Normalization → Normalized iris

Eye image

Quantization

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Ocular “Forensics”

- The eye and its immediate surroundings
- Consists of iris, sclera, eyelids, eyelashes, eyebrow, skin texture, etc.
Images from Smartphone
Variations in Iris Color

Brown Dark ~ Light

Light/Brown Green

Blue

Dark-colored Iris

COLOR IMAGE

NIR IMAGE

DARK IRIS

LIGHT IRIS
Iris “Forensics”

- **Visual Iris Matching:**
  - Human interpretable features for iris matching

- **Texture Analysis:**
  - Gender and Ethnicity
  - Biological age
  - Disease

- **Post-mortem**
  - Degradation of iris after death

- **Image Forensics:**
  - Deducing *sensor* from image
  - Deducing *illumination* source from image
Human interpretable features for iris matching
Utilizing anatomical features such as crypts, contraction furrows, collarette
Using Macrofeatures

- Freckles
- Moles: Small pigmented clusters of uveal melanocytes
- Nevi: Dark pigmented lesions
- Iris Melanoma: Tumors causing distortion of pupil
- Blood Vessel spots
Macrofeatures: Example #1
Macrofeatures: Example#2

- Pigmentation spots
- Brushfield spots
- Or
- Wolfflin nodules
Macrofeatures: Example #3

[Image of an eye with a sectoral heterochromia indicated by an arrow]
Each macro-feature is characterized by SIFT keypoints

A hit-rate of 92.8% at rank 1 is observed for a database of 770 color iris images where a subset of 380 images do not have any macro-features
Using Crypts

- Series of openings located on either side of the collarette that allow the stroma and deeper iris tissues to be bathed in aqueous humor

- **Thinning** of the anterior stroma thereby exposing the heavily pigmented epithelium
Matching Using Crypts

- F. Shen, Ph.D., 2014: A Visually Interpretable Iris Recognition System with Crypt Features
- Extracts “crypts” and “blob-like” structures from normalized iris images
Gender from Iris

- Tapia et al, “Gender Classification from Iris Images using Fusion of Uniform Local Binary Patterns”, ECCVW 2014

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Left eye (%)</th>
<th>Male (%)</th>
<th>Female (%)</th>
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<td>Raw Image</td>
<td>78.52 +/- 1.70</td>
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<td>LBP(8,1)</td>
<td>71.33 +/- 0.80</td>
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<td>ULBP(8,1)</td>
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<td>C-LBP-Sign (8,1)</td>
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- 750 males
- 750 females
- 80% training
- 20% testing
- Cross-validation
The medical literature suggests that changes to the iris texture and structure are possible. Two such changes:

- “Due to aging or trauma, atrophic areas may appear on the iris, resulting in a ‘moth-eaten’ texture”
- Iris melanomas: “The average age at diagnosis is 40-50 years; however, persons of any age can be affected”

The impact of these specific changes on iris recognition is unknown.
Changes in Pigmentation and Pupil

- Iris **color changes** with age in 10-15% Caucasians

- Pupil becomes **myotic** with age: excessive contraction of the pupil of the eye

- Under dim light, pupil of older people **dilates less** compared to pupil of younger people

- **Rubeosis iridis** is a medical condition of the iris in which **new abnormal blood vessels** are found on the surface of the iris
Changes in Cornea

- **Arcus senilis**: An opaque arc or ring around the peripheral cornea - represents fatty or oily deposits in the cornea.

- It is usually seen in **elderly** people.

- **Arcus juvenilis** is seen in people younger than 40 and often indicates high levels of cholesterol in the blood.

http://www.flickr.com/photos/ambistudies/4147687397/
Changes in Furrows

- Furrow **degeneration** or senile marginal degeneration
- Stromal **fibrillar degeneration** seen in rheumatoid arthritis
- Peripheral **melting** can occur

http://www.flickr.com/photos/ambistudies/4147711777/in/photostream/
Post-Mortem Iris Recognition

- The pupillary margin became indistinguishable in certain eye images; which made identifying the boundary of the pupillary margin difficult.
- In certain cases iris tissues were difficult to differentiate from adjacent scleral tissues, making limbal boundary indistinct.
- Iris images in the postmortem scenario were observed to develop corneal opacity.

Derakhshani et al, “Post Mortem Ocular Biometric Analysis,” CIteR Project, 2011
Classification accuracy is ~90%

Kalka, Bartlow, Cukic, Ross, “Identifying Sensors from Iris Images,” Manuscript under preparation
Determining Data Source

CASIA V2

ICE 2005

IITD
Which Dataset is this Image From?

- Classification accuracy ranged from 70% to 82%

El Naggar, Ross, “Which Dataset is this Iris Image From?” (Manuscript Under Preparation)

<table>
<thead>
<tr>
<th>Dataset</th>
<th>MBGC</th>
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Summary

- Iris forensics is an emerging area of research in academia

- Potential to exploit iris as a forensic modality:
  - Iris matching in a court of law
  - Resolving identity using “in-the-wild” images
  - Deducing ancillary information from iris texture
  - Determining imaging source of iris data
  - Genetics of human iris