Iris as a Forensic Modality: The Path Forward

Arun Ross

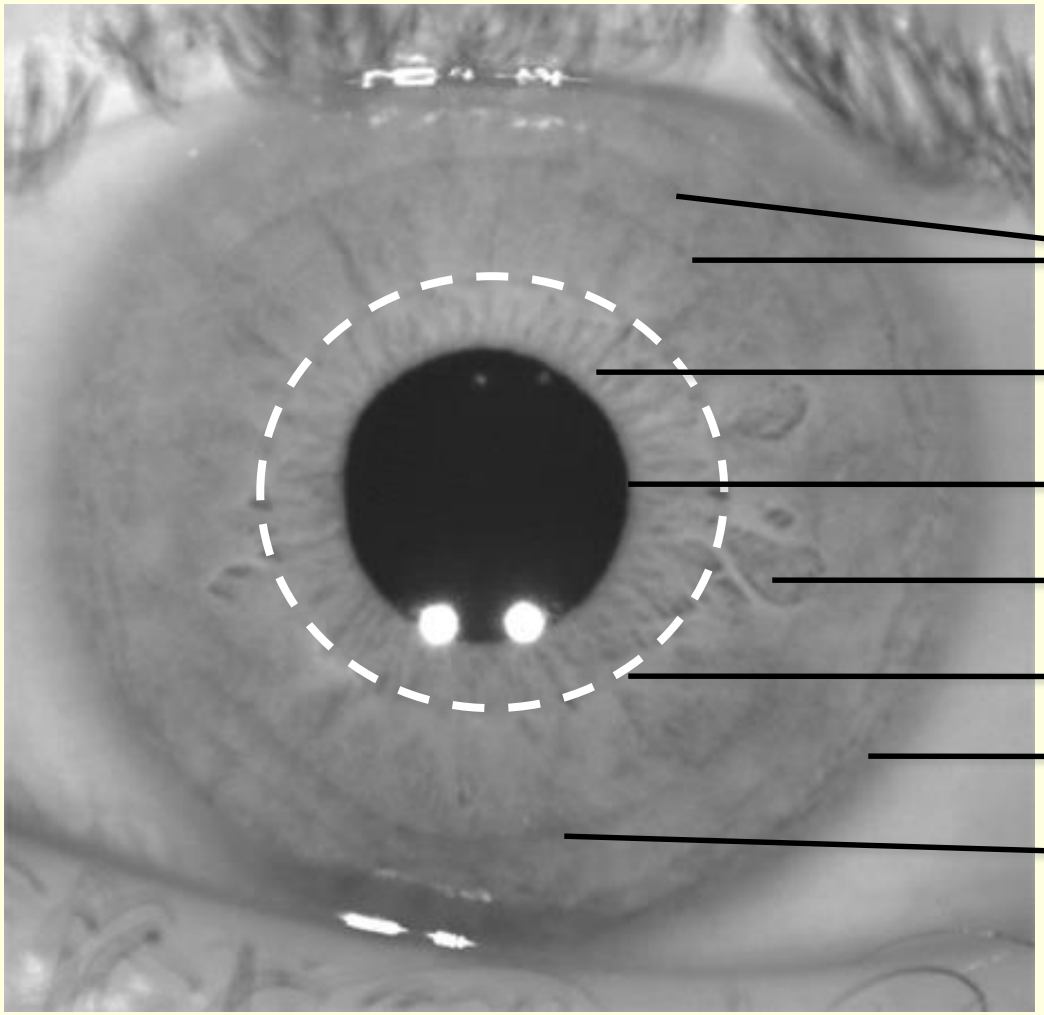
Associate Professor

Michigan State University

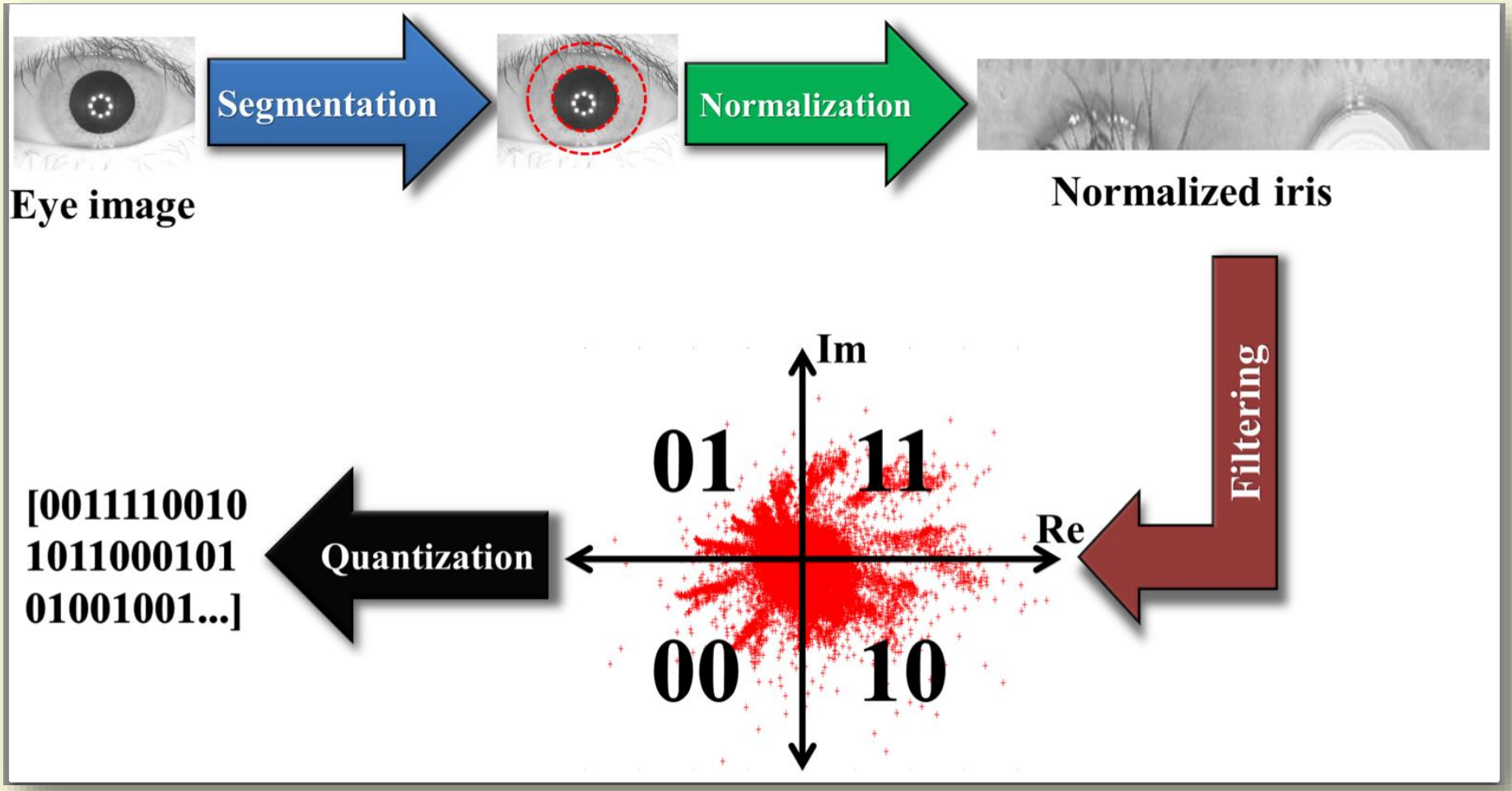
rossarun@cse.msu.edu

http://www.cse.msu.edu/~rossarun

Anatomy of the Iris



Automatic Iris Encoding



Ocular "Forensics"

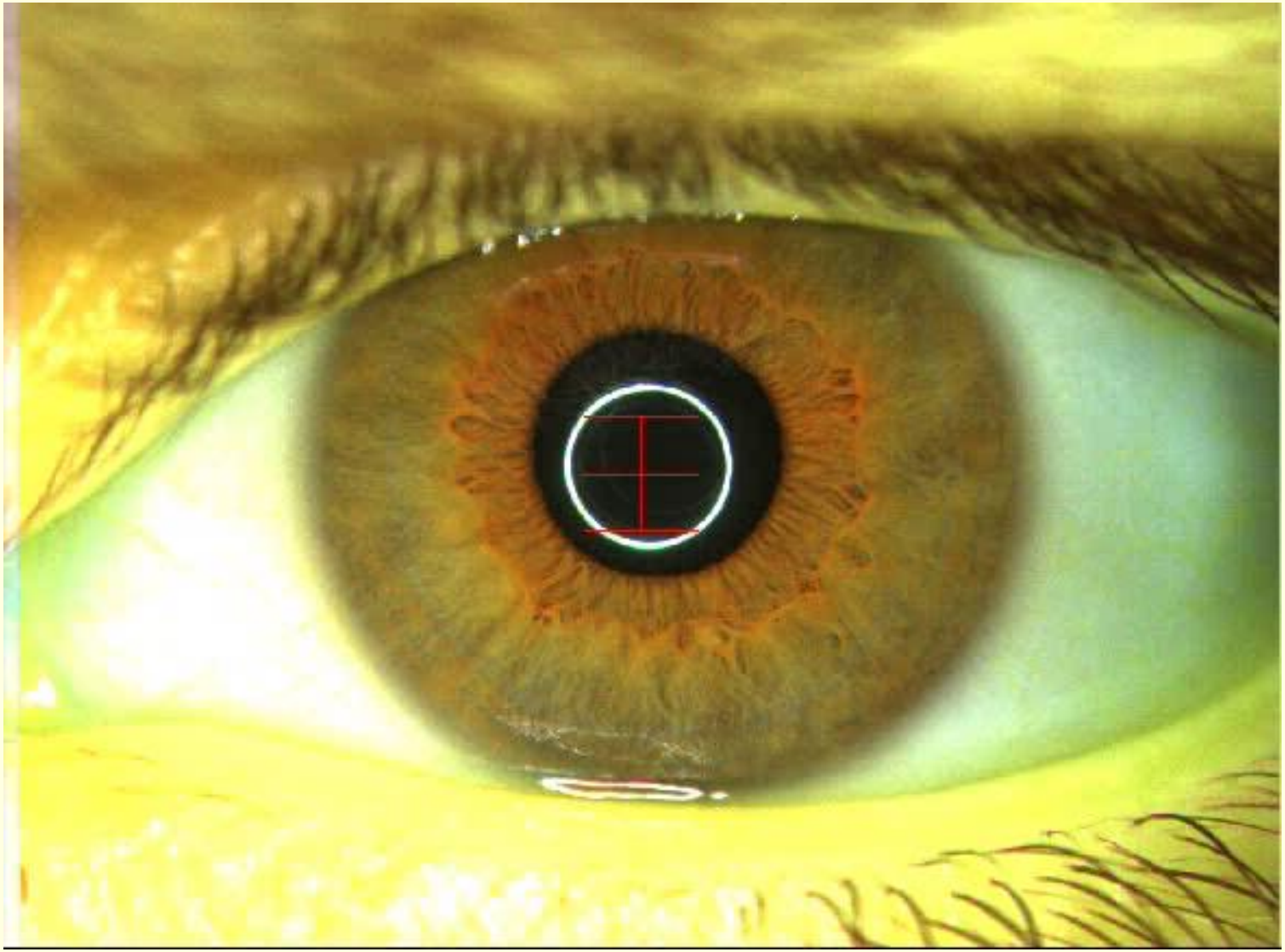
- The eye and its immediate surroundings
- Consists of iris, sclera, eyelids, eyelashes, eyebrow, skin texture, etc.

Images from Smartphone





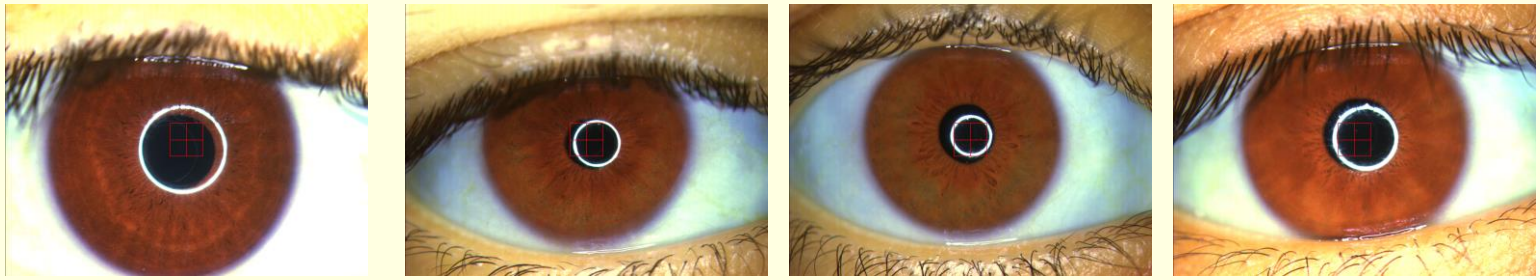

Color Iris



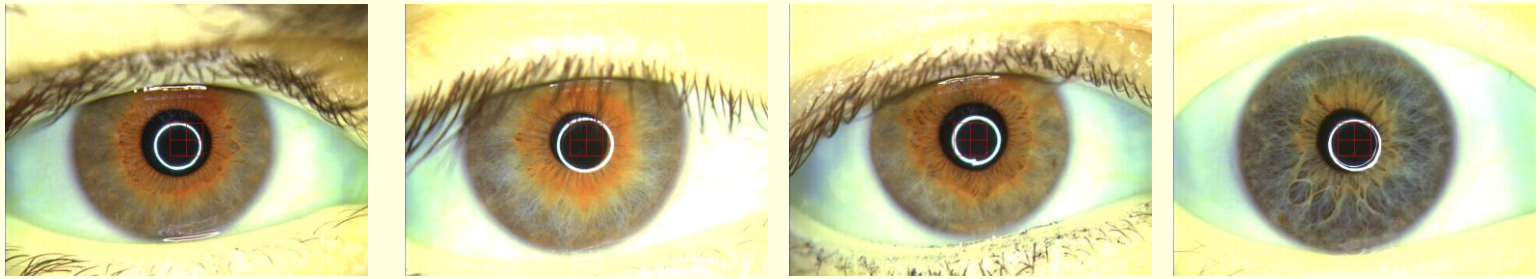
Variations in Iris Color

Brown Dark~Light

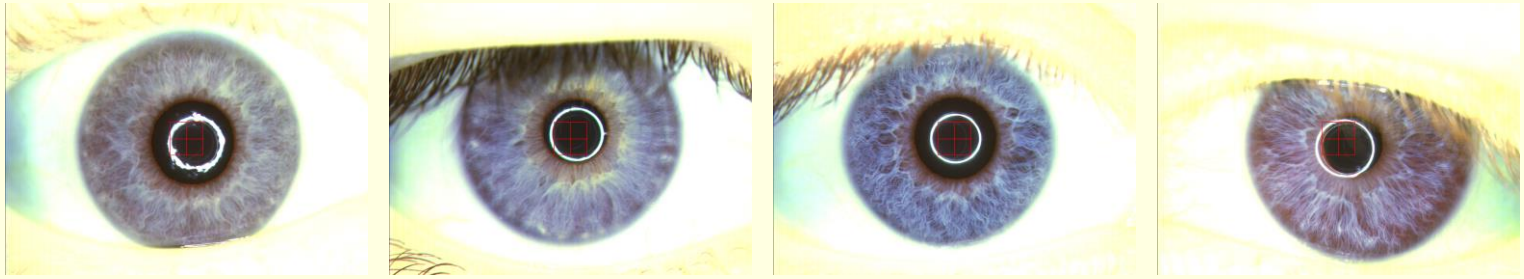
Orig Image dimension: 1300 x 1040



Light/Brown Green



Blue



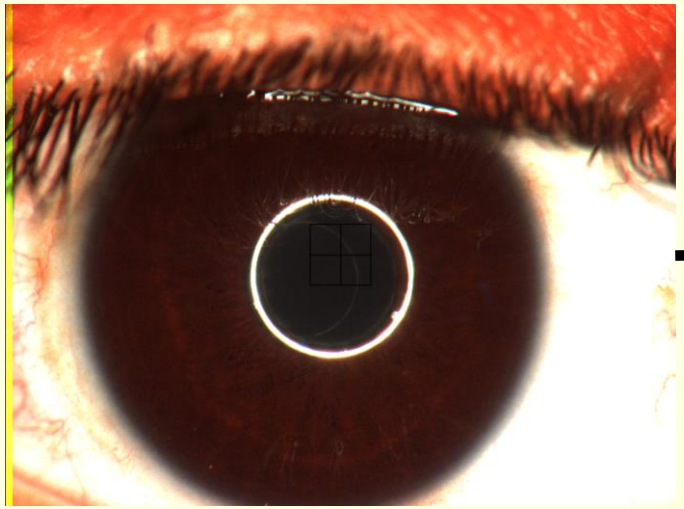
Boyce et al, "Multispectral Iris Analysis: A Preliminary Study," CVPR 2006

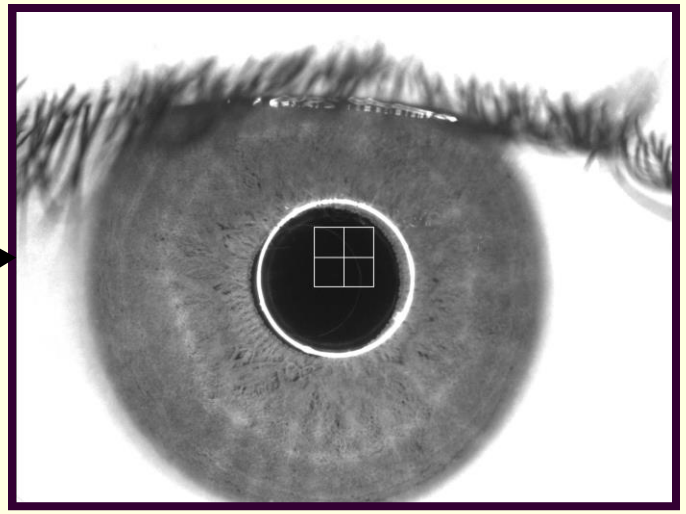
Dark-colored Iris

COLOR IMAGE

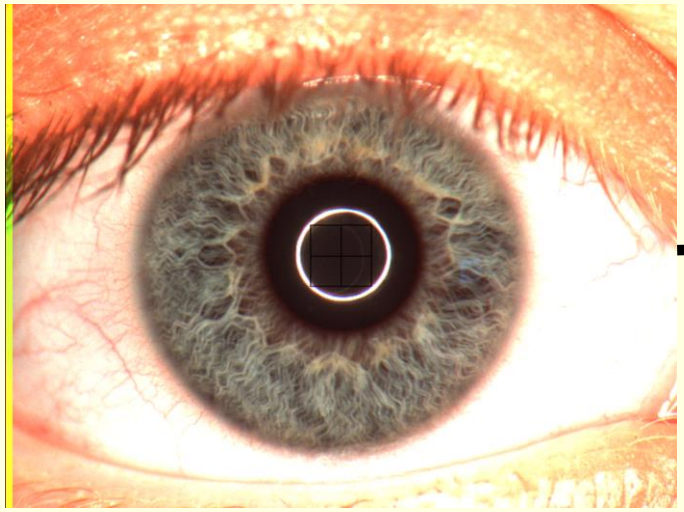
NIR IMAGE

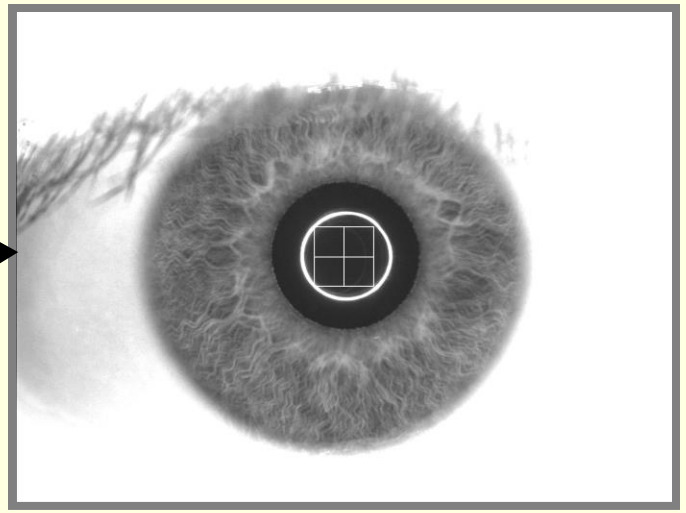
DARK IRIS





LIGHT IRIS



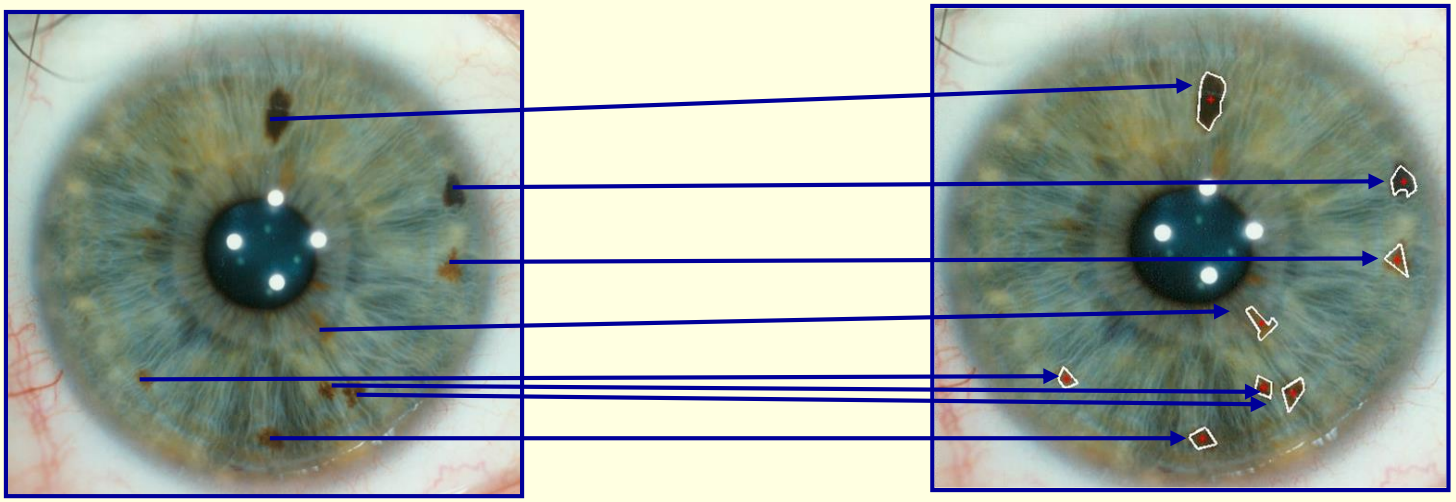


Iris "Forensics"

- 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

Manual Iris Matching

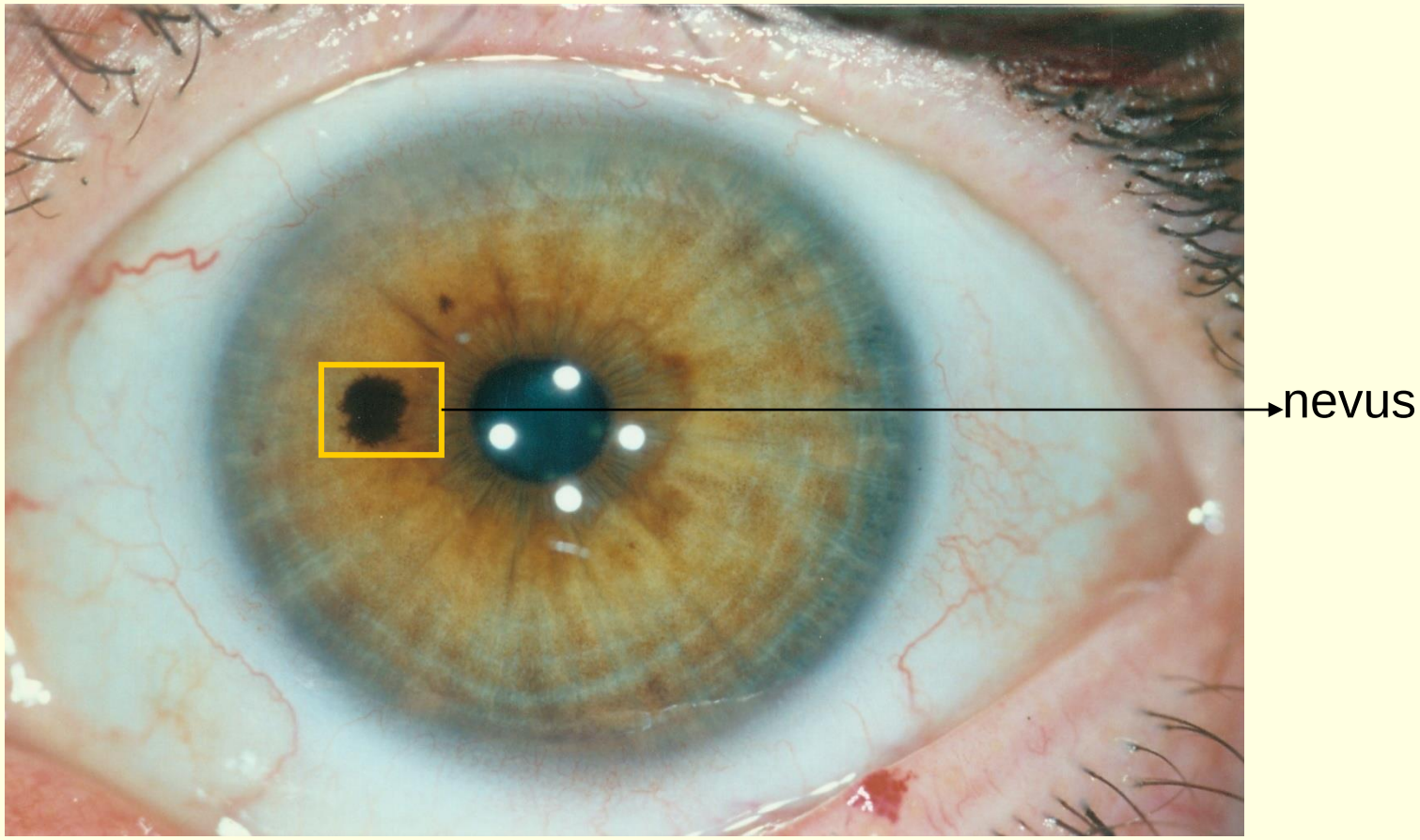
- Human interpretable features for iris matching
- Utilizing anatomical features such as crypts, contraction furrows, collarette



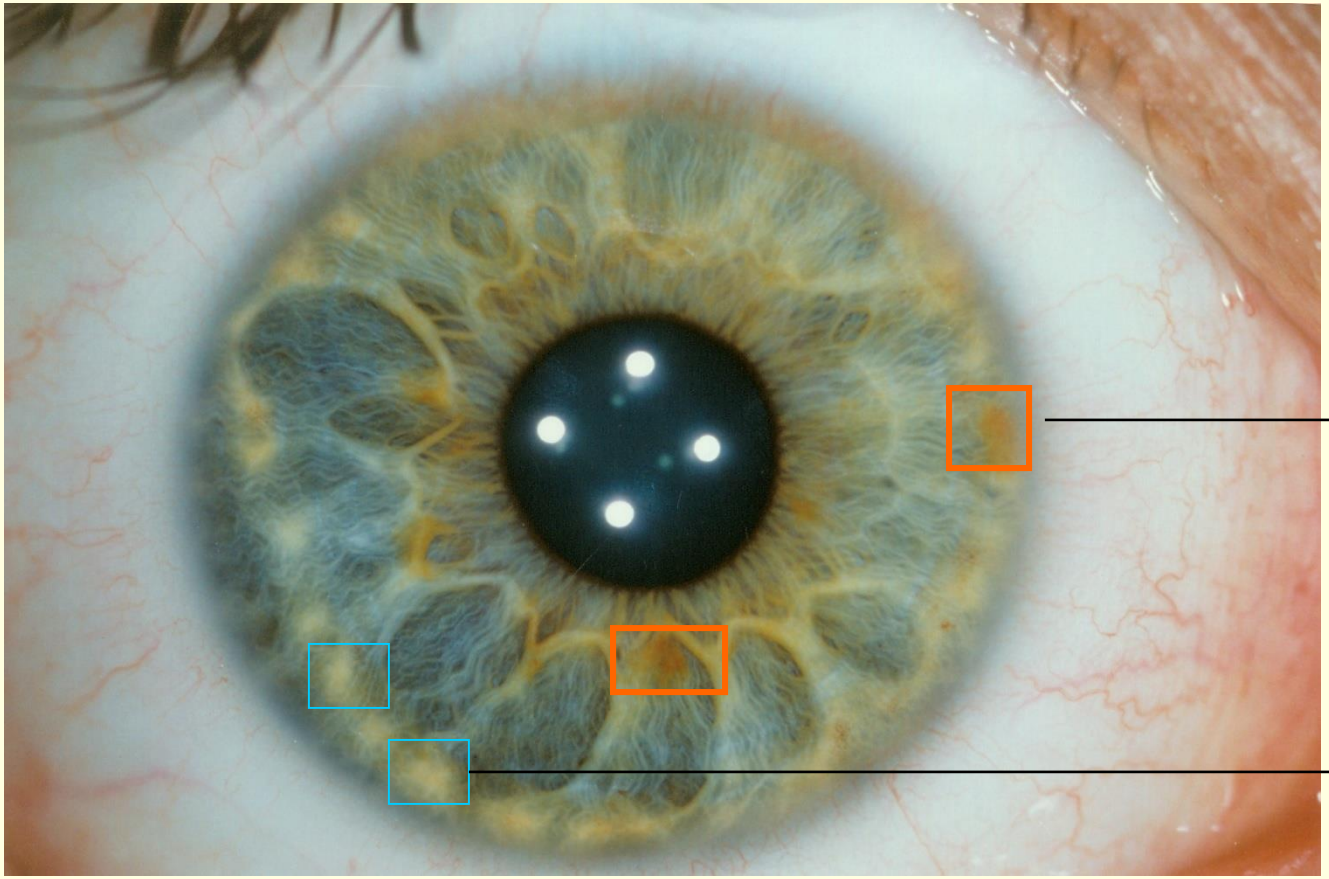
Using Macrofeatures

- 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



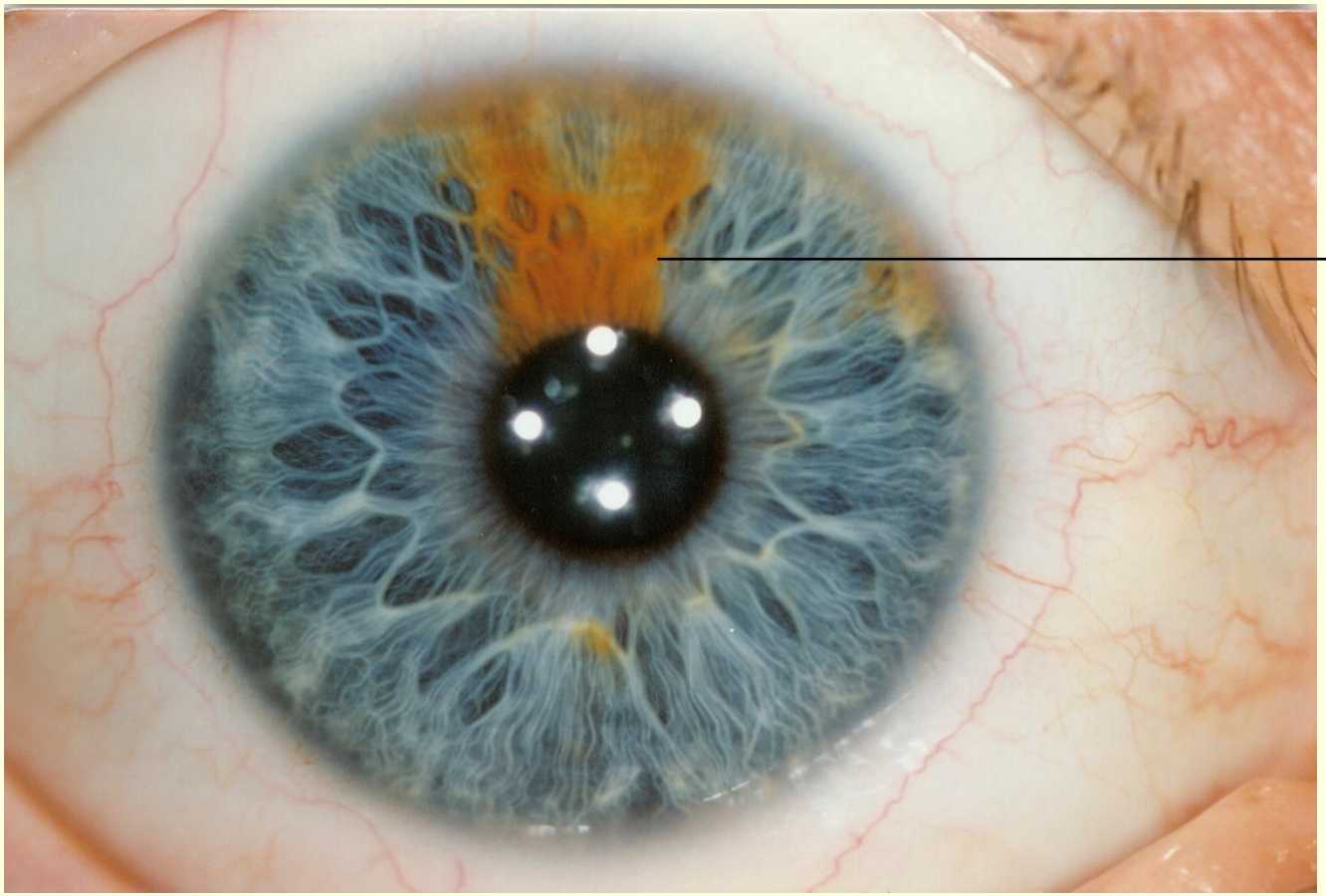
Macrofeatures: Example#2



Pigmentation spots

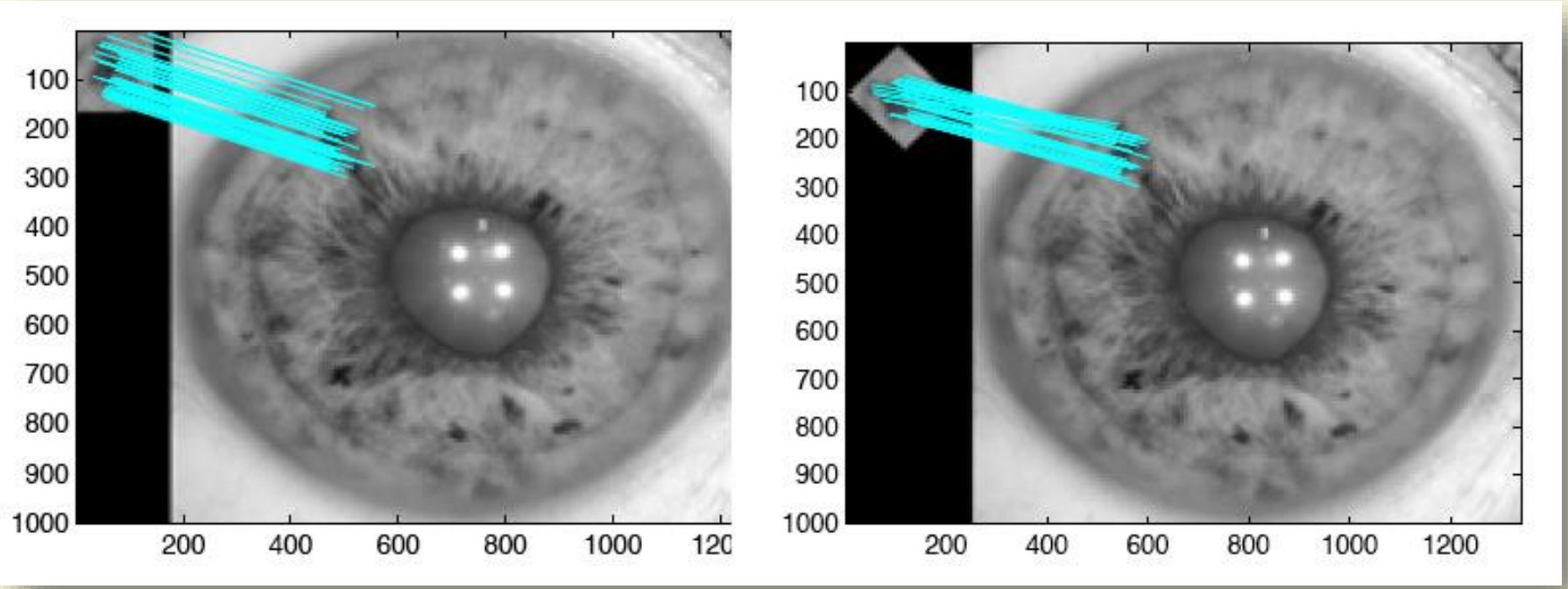
Brushfield spots
Or
Wolfflin nodules

Macrofeatures: Example#3



Matching Using Macro-features

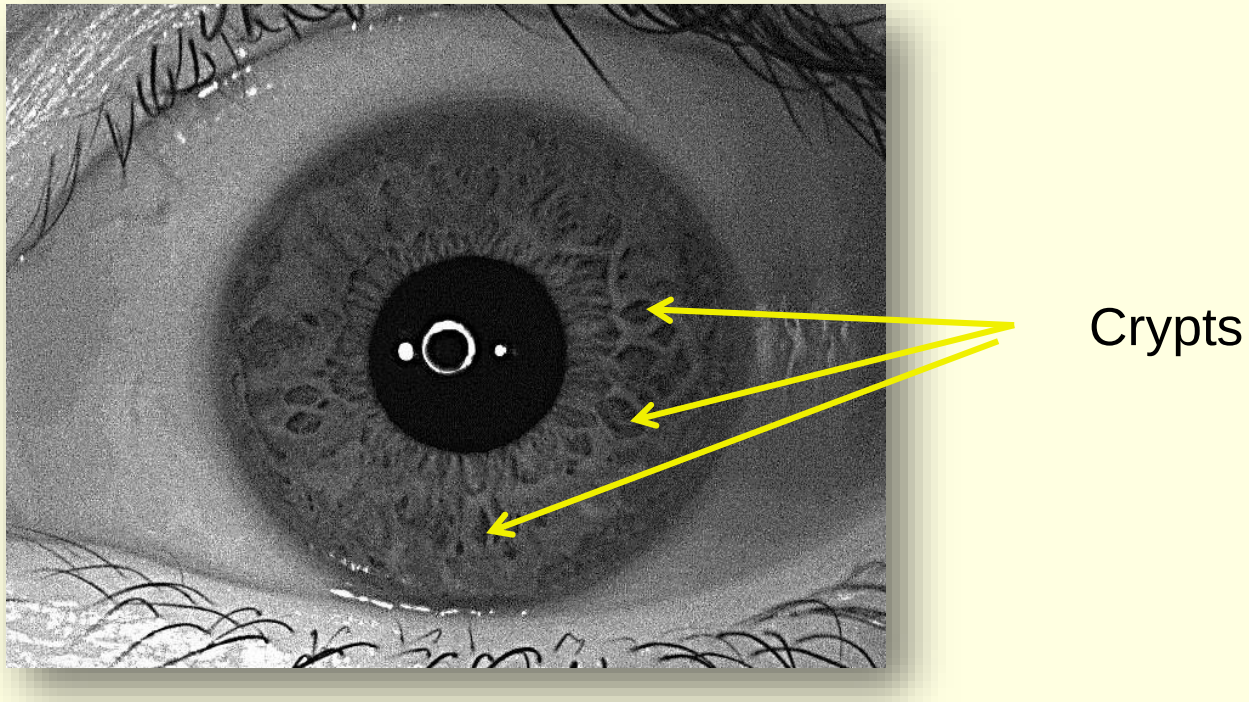
Sam Sunder and Ross, "Iris Image Retrieval Based on Macro-features," ICPR 2010



- 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

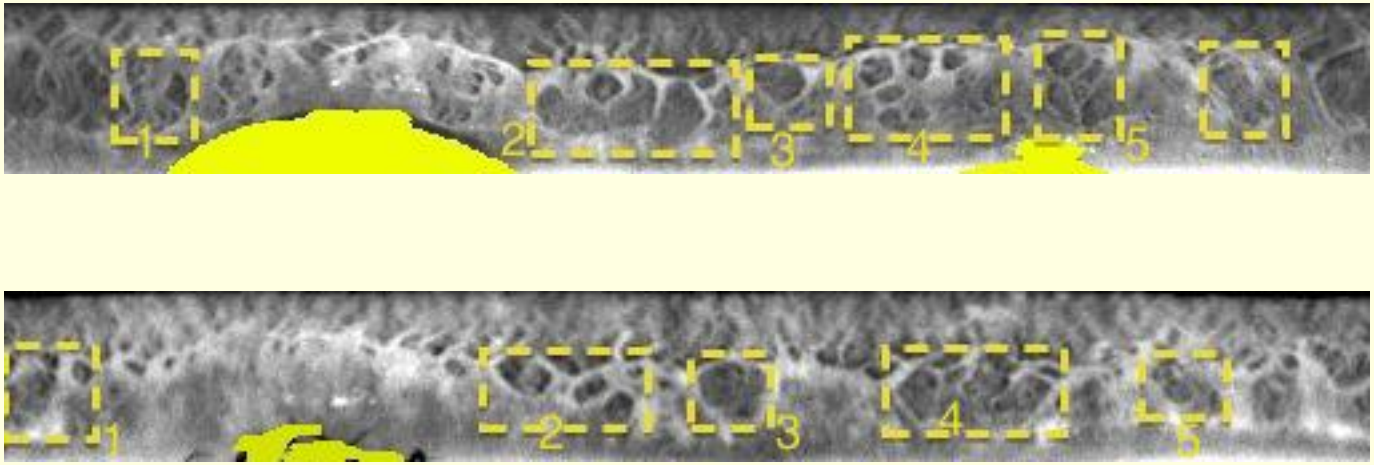
Using Crypts

- 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

Implementation	Left eye (%)	Male (%)	Female (%)
Raw Image	78.52 +/- 1.70	77.50	79.53
LBP(8,1)	71.33 +/- 0.80	70.00	73.16
ULBP(8,1)	77.33 +/- 0.70	74.33	80.30
C-LBP-Mag(8,1)	65.33 +/- 0.90	68.25	62.35
C-LBP-Sign (8,1)	60.33 +/- 0.80	58.30	62.33
C-ULBP-Mag(8,1)	81.33 +/- 0.50	84.00	80.00
C-ULBP-Sign (8,1)	77.33 +/- 0.50	76.13	78.66
LBP-Fourier(8,1)	68.33 +/- 0.67	69.50	67.10
LBP-Fourier(16,2)	62.33 +/- 0.35	59.00	65,66
ULBPh(8,1)	90.33 +/- 0.35	92.67	88.00
ULBPh_ov(8,1)	**91.33** +/- 0.40	**96.67**	**86.00**

- **750 males**
- **750 females**
- **80% training**
- **20% testing**
- **Cross-validation**

Biological Changes to the Iris

- 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

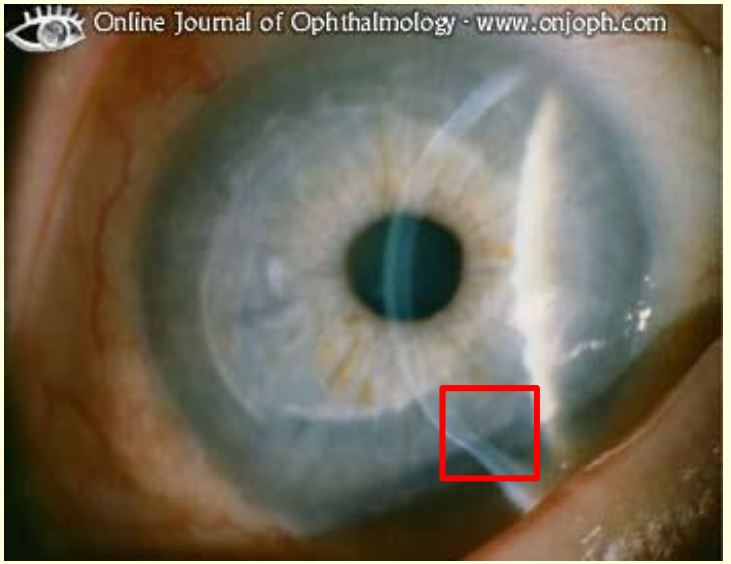
- It is usually seen in elderly people

- 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

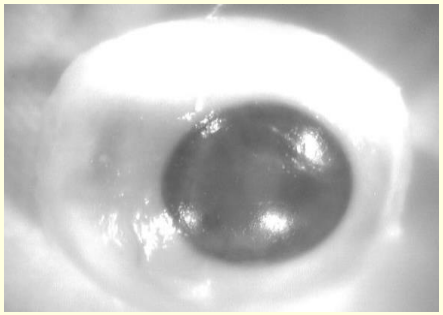
- Furrow degeneration or senile marginal degeneration
- Stromal fibrillar degeneration seen in rheumatoid arthritis
- Peripheral melting can occur



http://www.flickr.com/photos/ambistudies/4147711777/in/photostream/

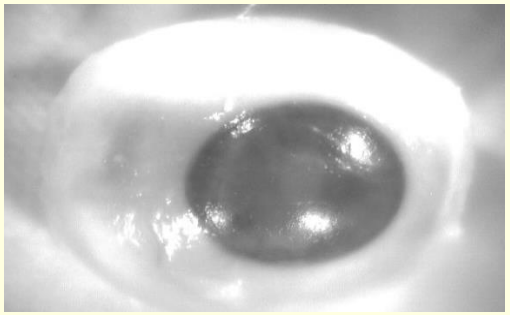
Post-Mortem Iris Recognition

- 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



Pupil fadeout

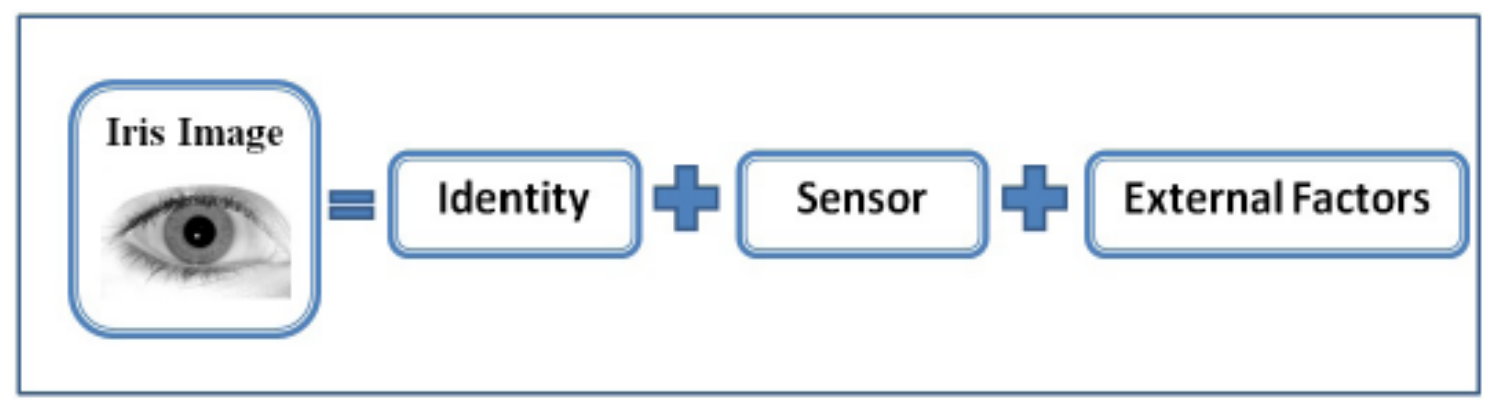
Limbic boundary diffusion



Corneal Opacity

Derakhshani et al, "Post Mortem Ocular Biometric Analysis," CITeR Project, 2011

Determining Sensors from Images

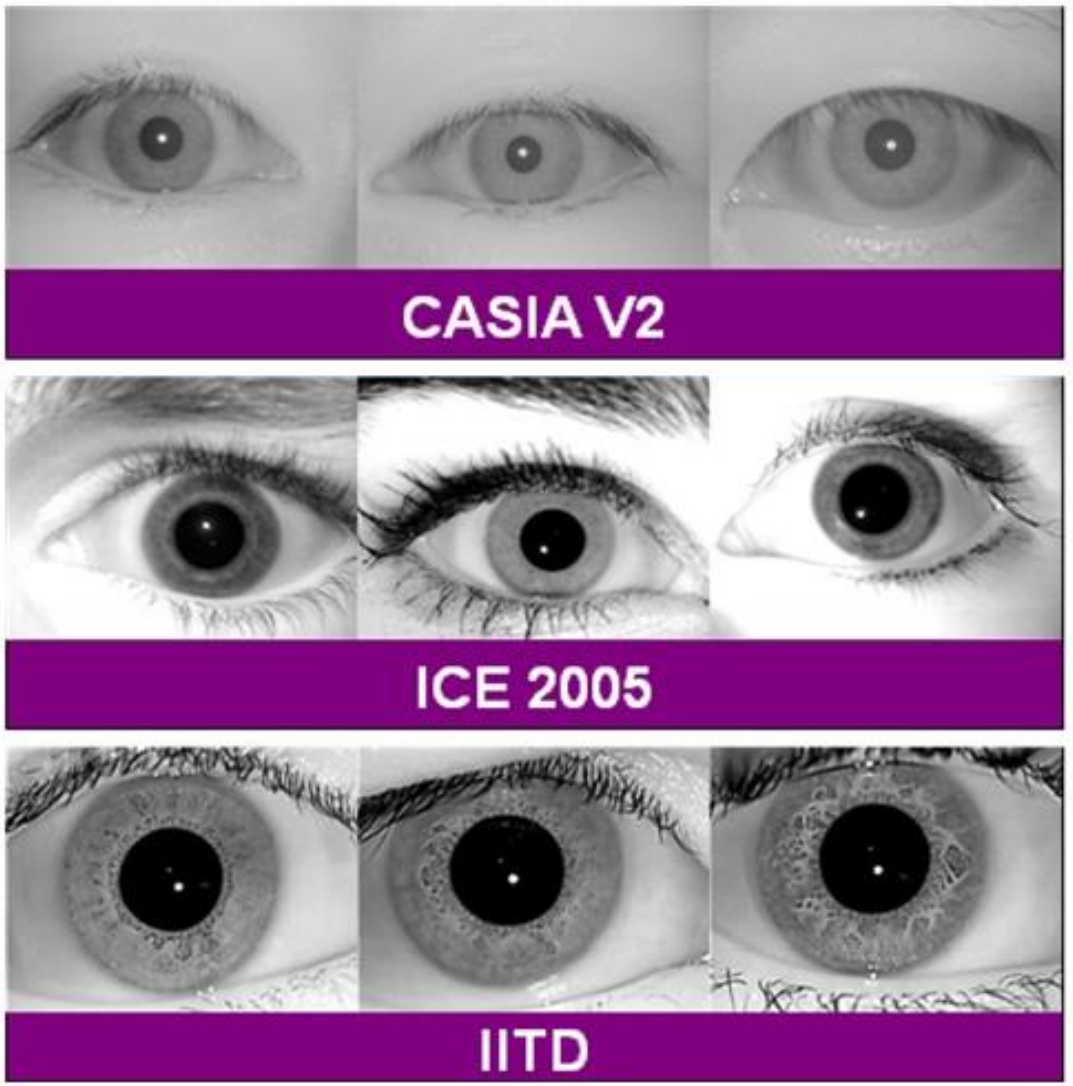


- **Classification accuracy is ~90%**

Kalka, Bartlow, Cukic, Ross, "Identifying Sensors from Iris Images," Manuscript under preparation

Actual \ Classified	ICE-LG	WVU-OKI	WVU-EverFocus	CASIAv3-OKI	CASIAv3$_p$	CASIAv2-OKI	CASIAv2$_p$
ICE-LG	1680	0	0	0	0	0	0
WVU-OKI	0	1680	0	0	0	0	0
WVU-EverFocus	9	0	1661	0	0	10	0
CASIAv3-OKI	0	0	0	1665	0	15	0
CASIAv3$_p$	103	155	47	210	1009	82	74
CASIAv2-OKI	0	0	0	0	0	1680	0
CASIAv2$_p$	0	0	0	0	0	0	1680

Determining Data Source



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)

Dataset	MBGC	CASIA V3	UPOL	UBIRIS	WVU	IITD	ICE	CASIA V2
MBGC	174	0	0	7	2	1	4	4
CASIA V3	0	185	0	0	1	0	1	5
UPOL	3	1	164	18	1	0	3	2
UBIRIS	5	0	19	162	2	0	4	0
WVU	4	5	5	2	156	5	6	9
IITD	0	0	0	0	0	192	0	0
ICE	26	0	25	13	15	7	105	1
CASIA V2	23	5	0	7	34	2	1	120

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

Iris as a Forensic Modality: The Path Forward

Arun Ross

Associate Professor

Michigan State University

rossarun@cse.msu.edu

http://www.cse.msu.edu/~rossarun