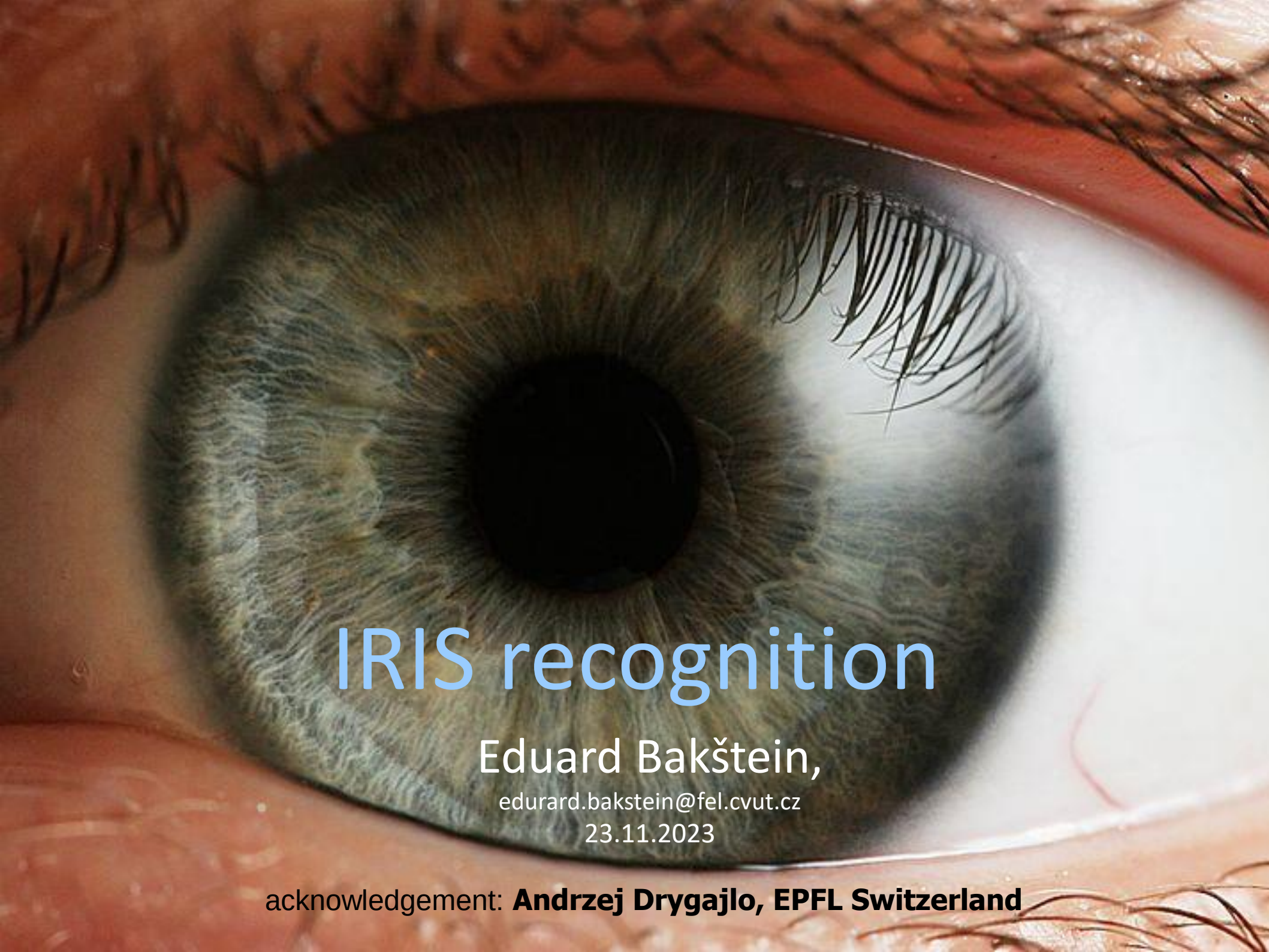


IRIS recognition

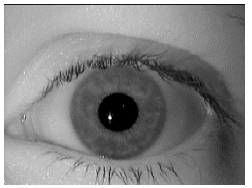
Eduard Bakštein,
edurard.bakstein@fel.cvut.cz
23.11.2023

acknowledgement: **Andrzej Drygajlo, EPFL Switzerland**

Motivation: Iris recognition process

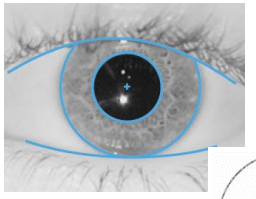
- Iris recognition process (Basic J. Daugmann approach and some modalities)

IN

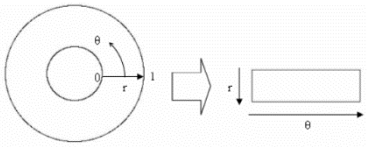


iris image

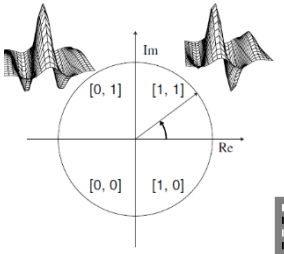
- Iris segmentation



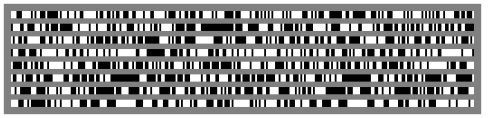
- Unwrapping



- Feature extraction

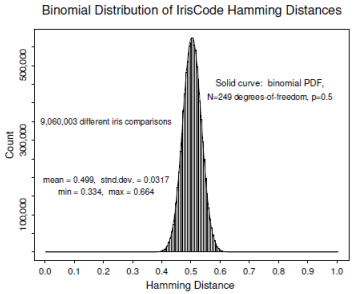


- Encoding



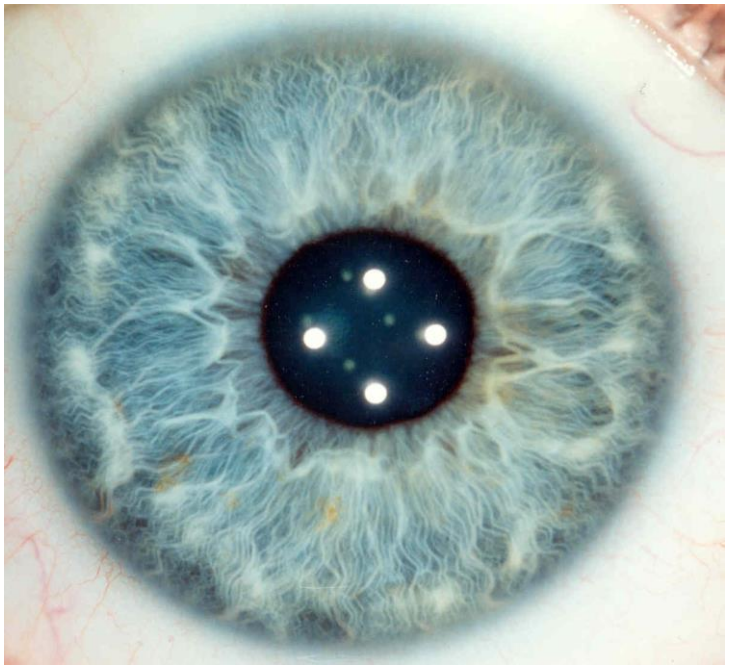
- Comparison

OUT



result of iris code comparison

Outline



- Introduction
- Basics
- Iridology
- Iris in biometry
- Properties of the Iris
- Sensing
- Applications
- Processing

Morpheus and Iris,
GUÉRIN, Pierre-Narcisse, 1811 (neoclassicissm), Hermitage

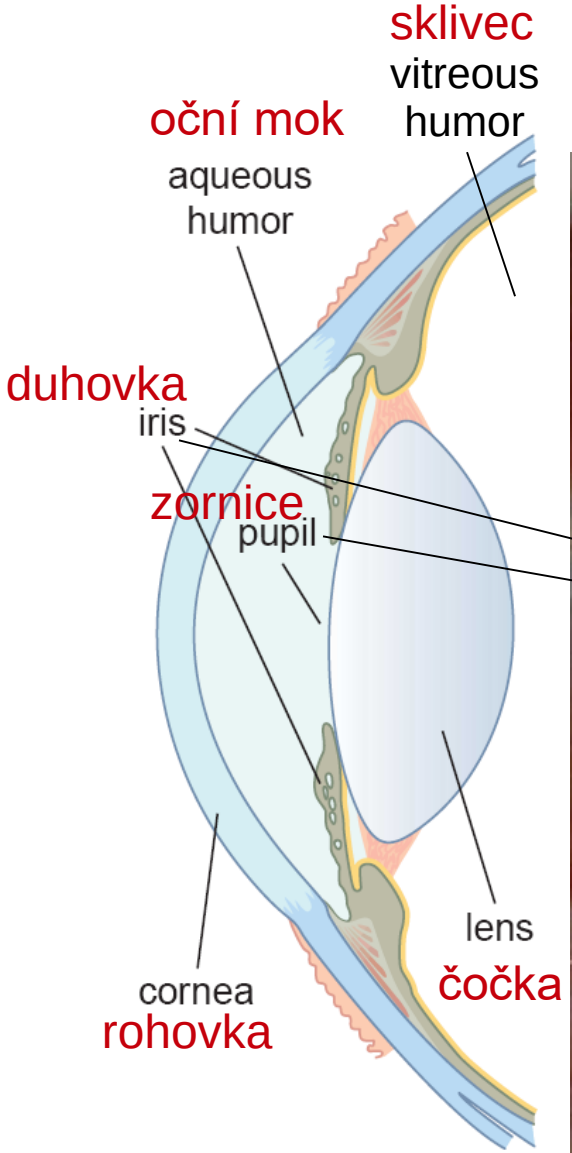
Ethymology

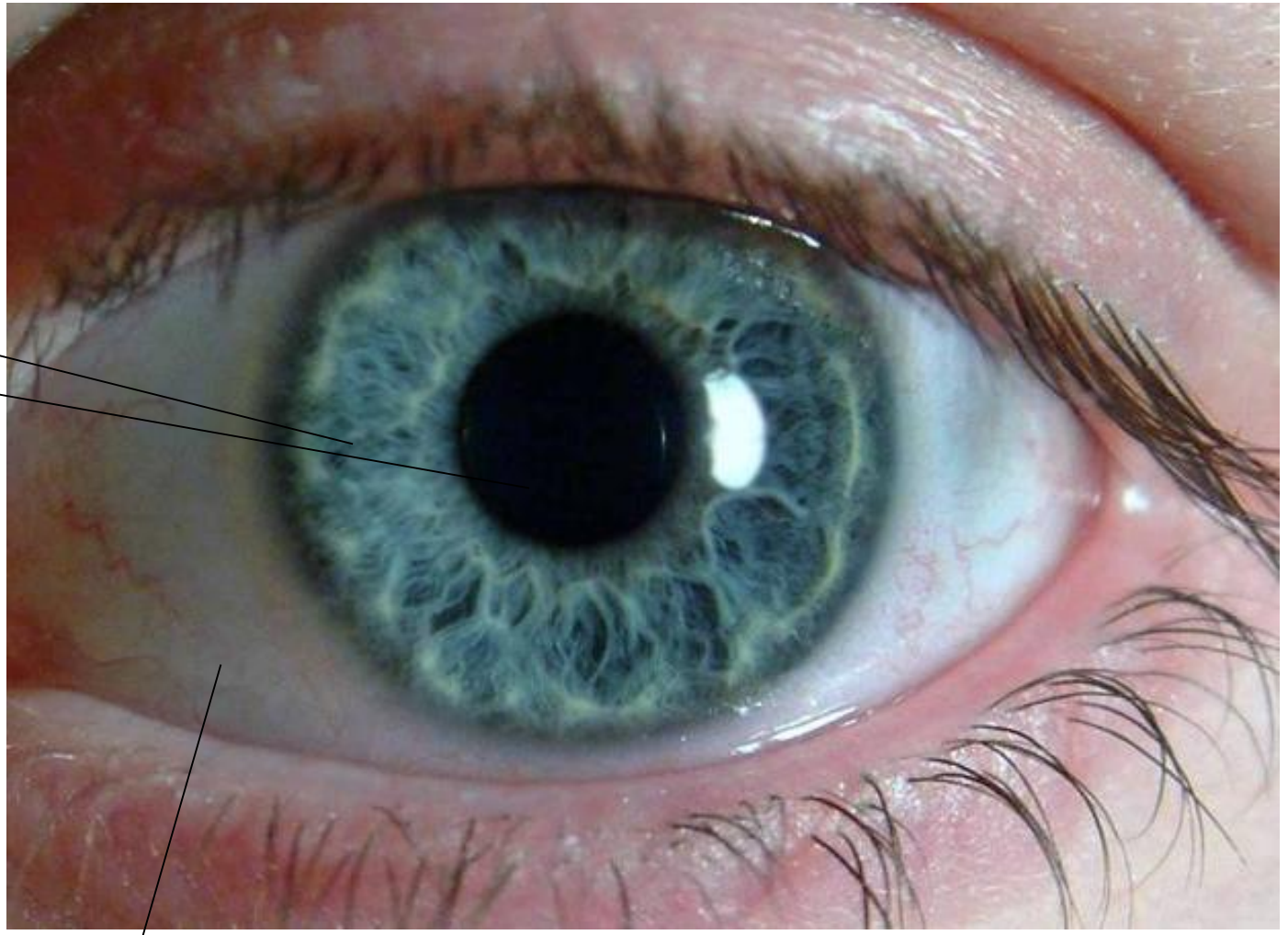
Iris: late 14c., flowering plant (Iris germanica), also "prismatic rock crystal," from L. iris (pl. irides) "iris of the eye, iris plant, rainbow," from Greek iris (gen. iridos) a rainbow; the lily; iris of the eye,

originally "messenger of the gods," personified as the rainbow. The eye region was so called (early 15c. in English) for being the colored part; the Greek word was used of any brightly colored circle, "as that round the eyes of a peacock's tail" [Liddell and Scott]

source: http://ethymonline.com

The IRIS (Basics)



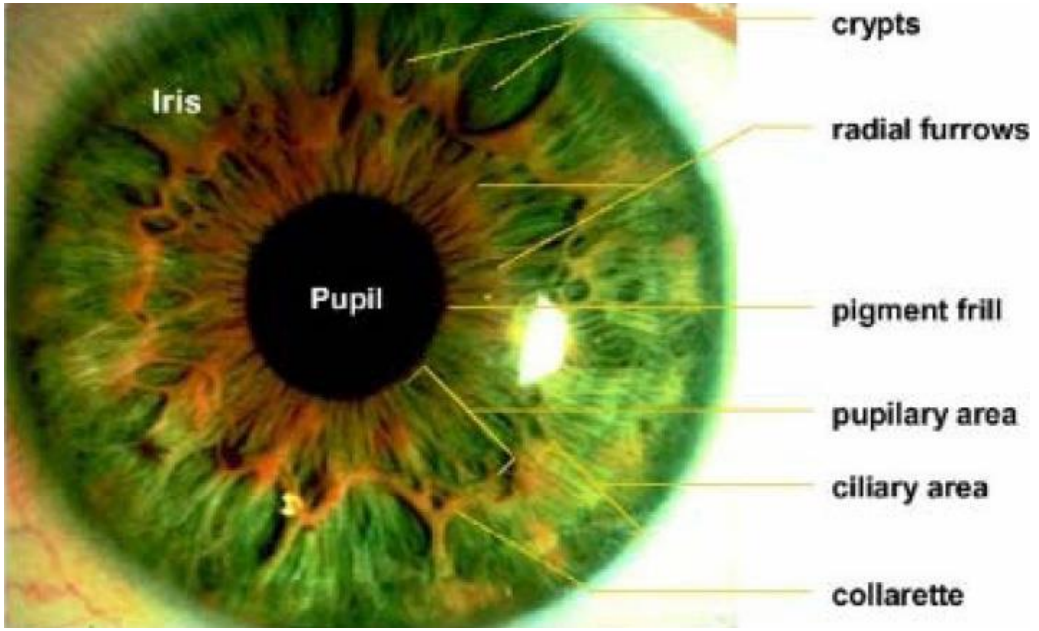


sclera
bělma

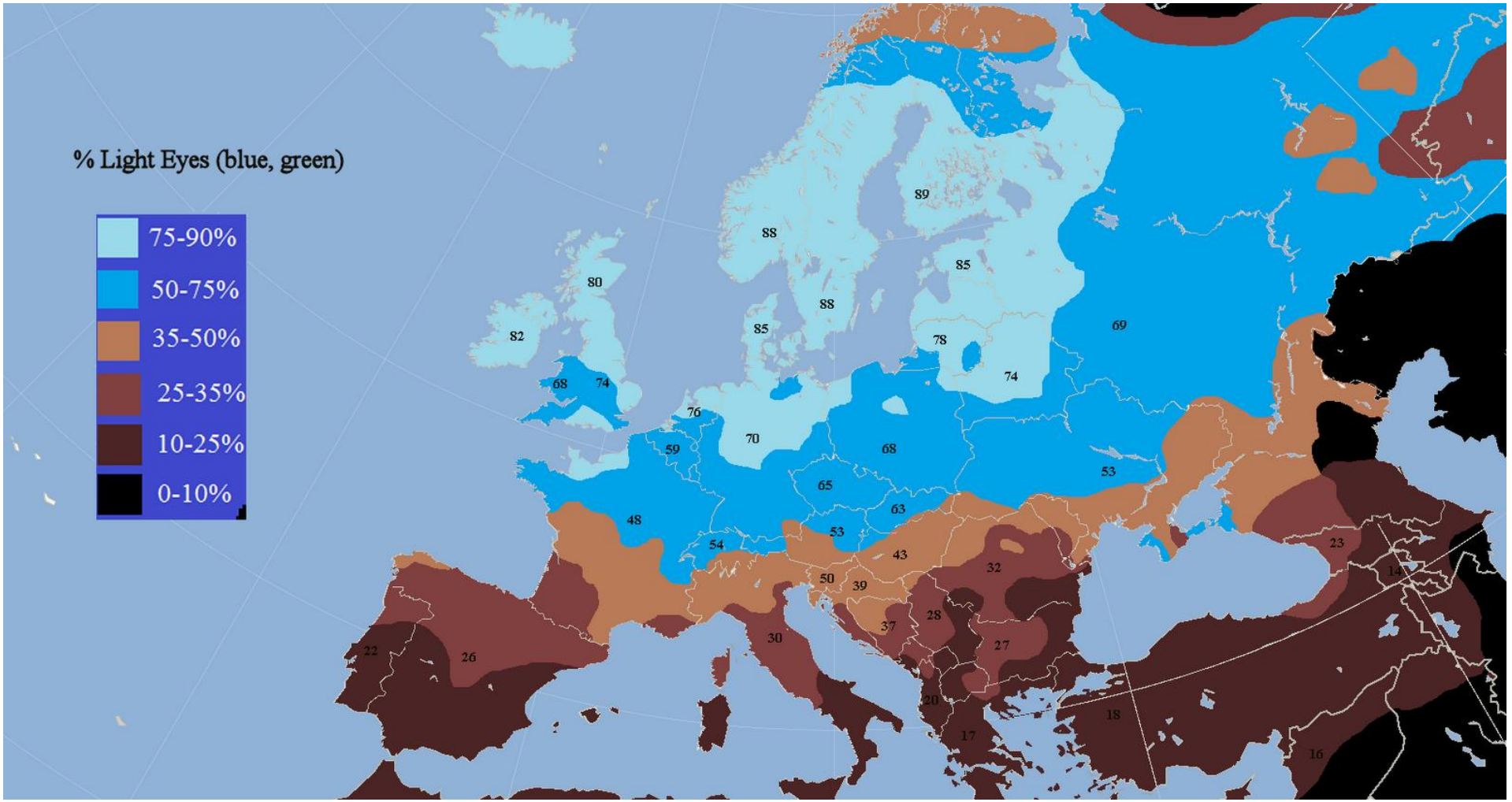
The IRIS (Basics II)

- most of the structure formed in 3rd - 8th month of gastation (prenatal periode)
- pigmentation can continue after birth
- iris color: mostly melanin pigment (blue iris = absence of pigment)

Distinctive features:
furrows, ridges, crypts, rings, corona, freckles etc.



Eye color



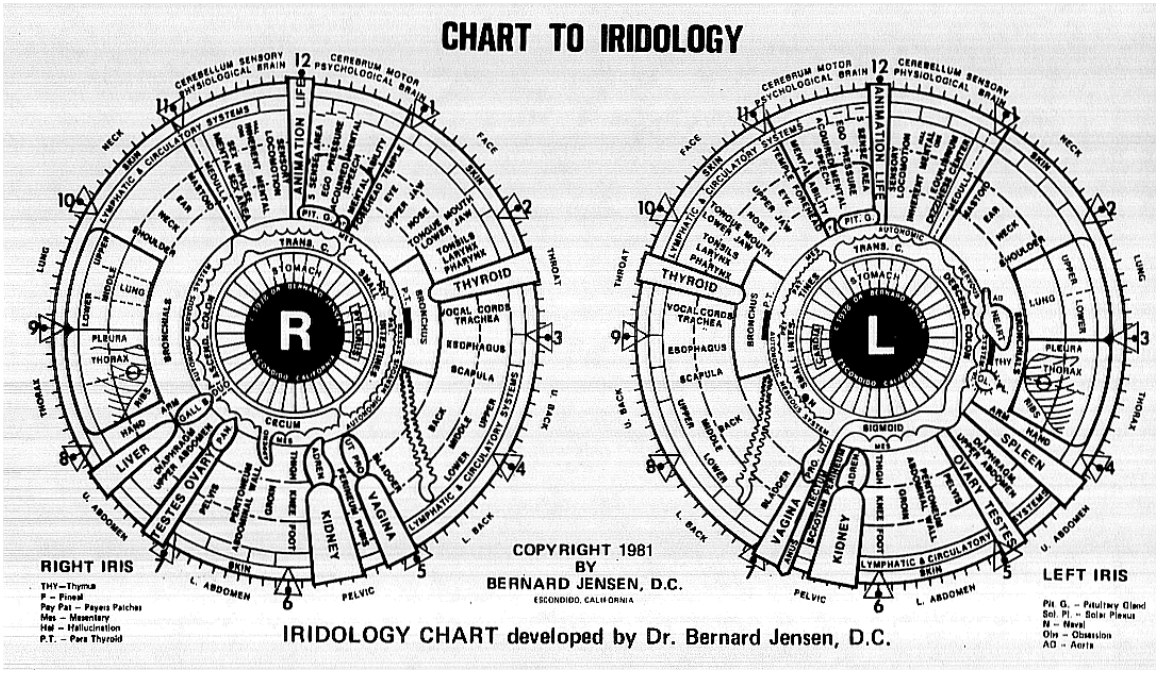
http://en.wikipedia.org/wiki/Eye_color

History of Iris recognition

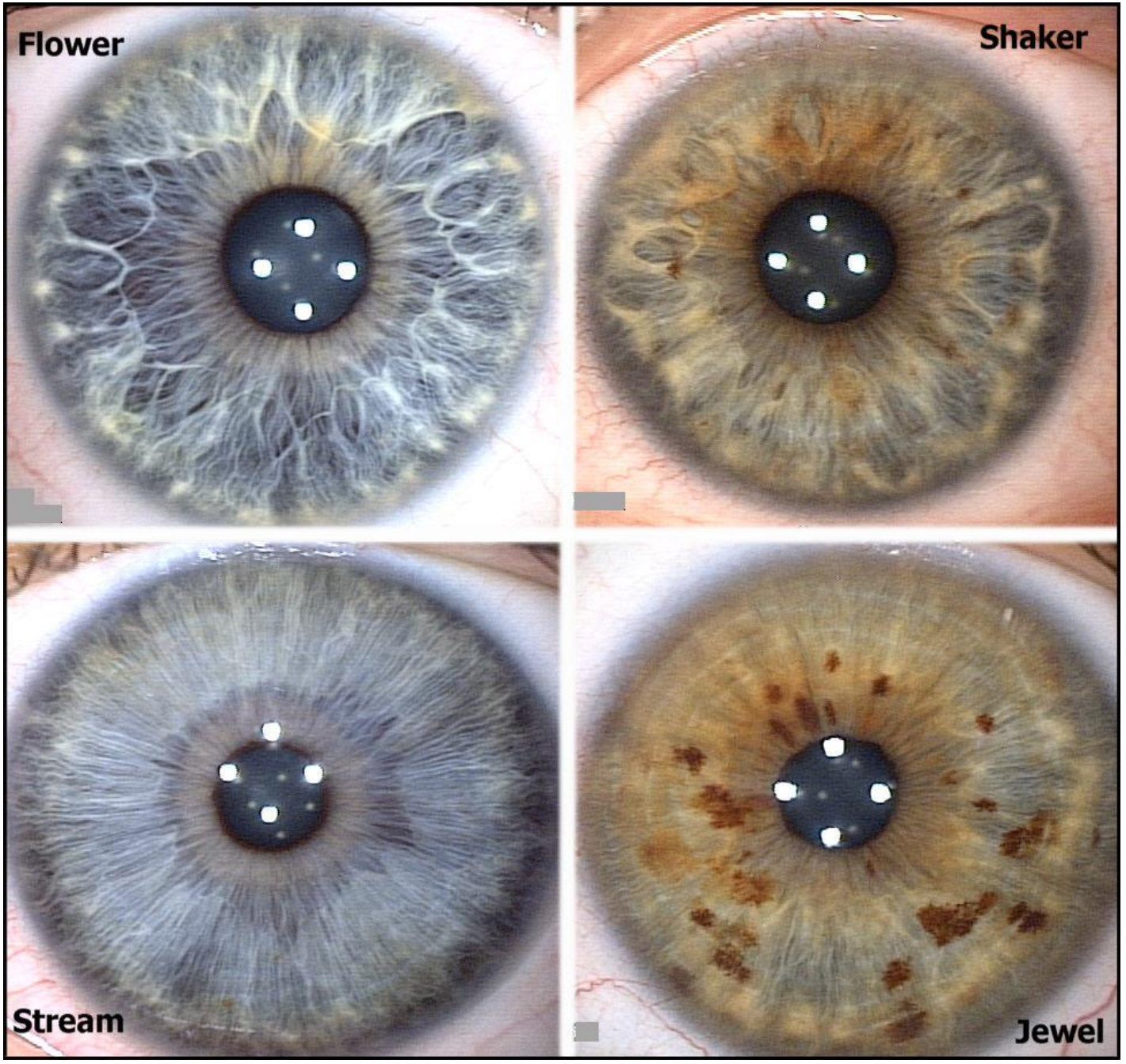
- Ancient civilizations - Ancient Egypt (~3000 B.C.), Ancient China Chaldea in Babylonia (~700 B.C.), Ancient Greece (~300 B.C.) - divination from iris
- 19th century - Ignaz von Peczely: iridology
- 1885 - Alphonse Bertillon: idea of using iris for personal identification (color and pattern type)
- 1949 - James Doggart: examined the complexity of iris patterns. Iris could be used instead of fingerprints
- 1987 - Flom, Safir: patented Doggart's concept
- 1989 - John Daugman invented and patented iris recognition system (basis of all commercially available systems)

Iridology

- Branch of alternative medicine
- Basics: Systematic changes in the iris pattern reflect the state of health of each of the organs in the body
- Matching observer properties of the iris pattern to *iris charts* (below)



Iridology (2)



Iridology (epilogue)

Iridologists:

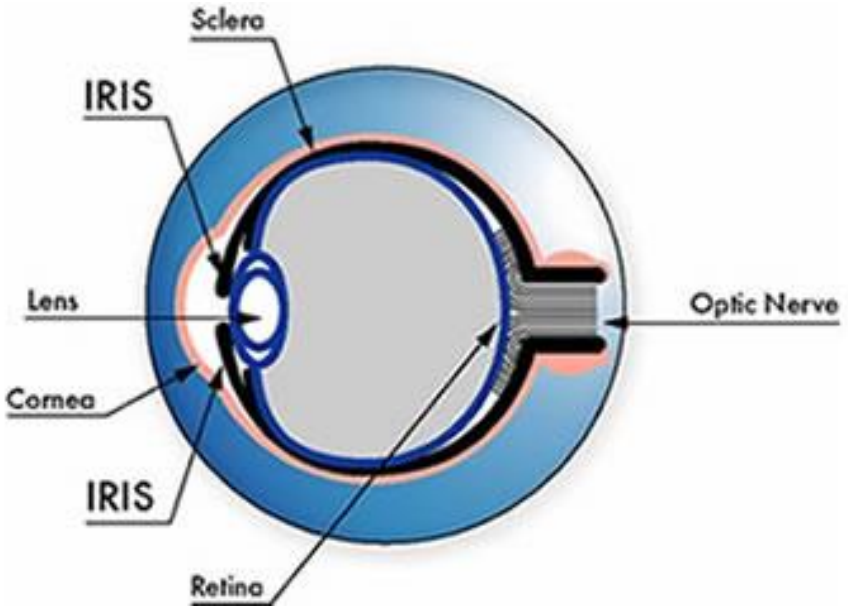
- Eye = “window to the soul”
- “Modern medicine neglects true roots of medical problems”

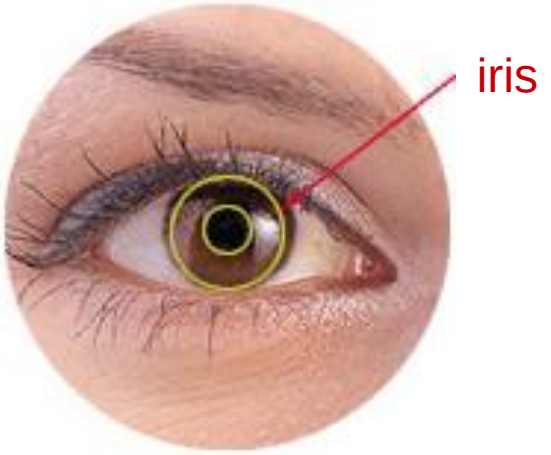
Medical experts:

- Iridology = medical fraud
- Supported by scientific tests
  - Berggren, L. (1985), “Iridology: A critical review”, *ActaOphthalmologica,*63(1): 1-8

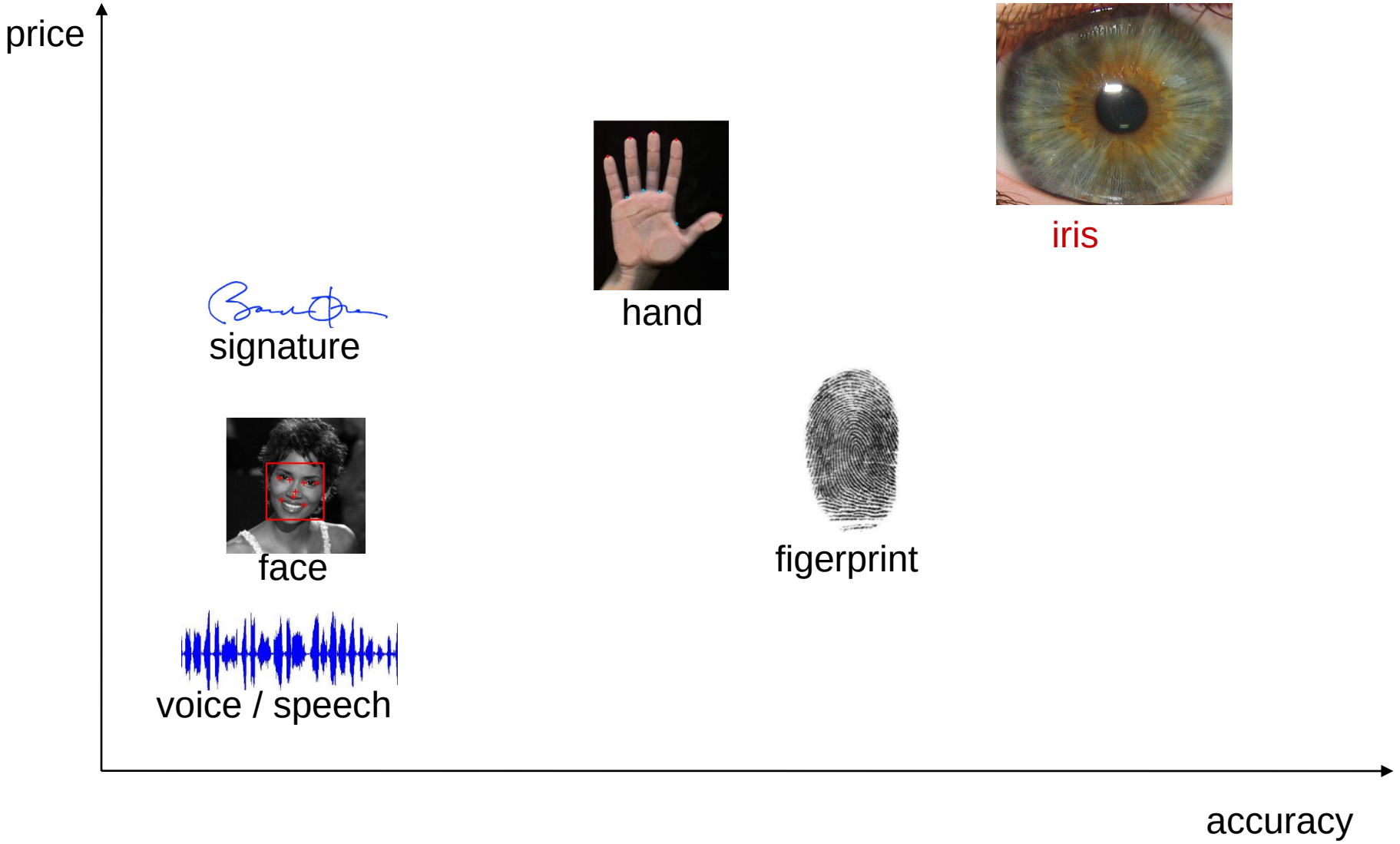
IRIS for biometry

- Well protected (internal organ of the eye, cornea)
- Externally visible from a distance
- Unique, highly complex pattern
- Stable over the lifetime (except pigmentation)





IRIS vs Other biometric techniques



Biometric characteristics

- Biological traces
  - DNA (DeoxyriboNucleicAcid), blood, saliva,etc.
- Biological(physiological) characteristics
  - fingerprints, eye irises and retinas, hand and palms geometry, facial geometry
- Behavioral characteristics
  - dynamic signature, gait, keystroke dynamics, lip motion
- Combined
  - voice

Genotypic vs Phenotypic

Genotypic - based on genetic makeup of a cell

- DNA, blood type, gender

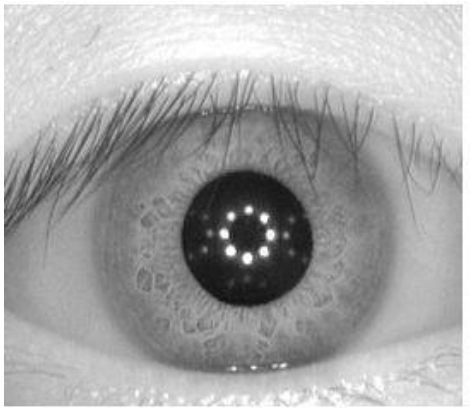
Phenotype - all observable properties of a living organism.

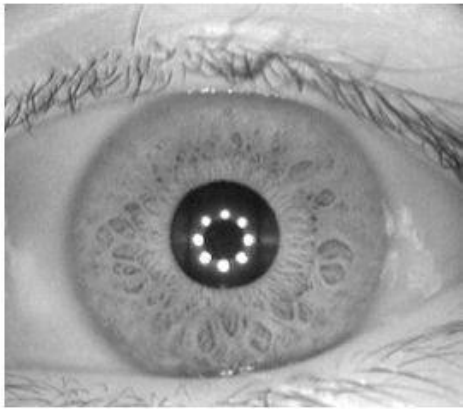
- fingerprints, iris (except eye color)

Phenotype = genotype + environment

Every biometric feature somewhere inbetween

Iris pattern is a phenotypic feature

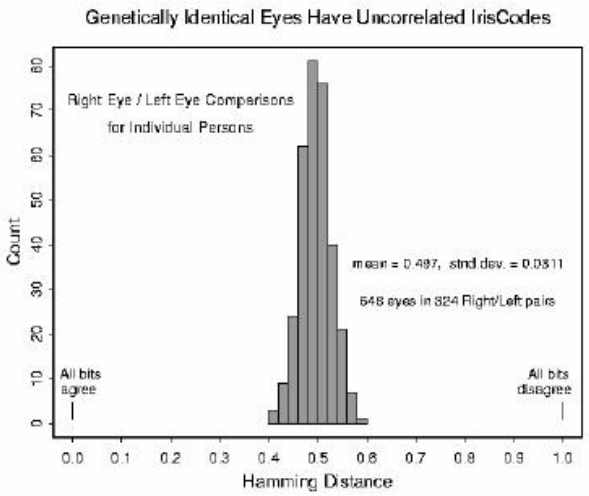




Proof: monozygotic twins

Genetically identical eyes have iris patterns that are uncorrelated in detail:

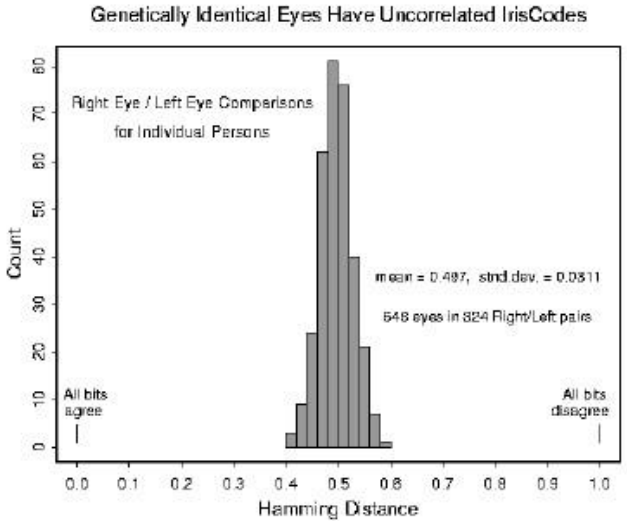
Monozygotic Twins B
(18 year-old women)



Monozygotic twins (2)

Genetically identical eyes have iris patterns that are uncorrelated in detail:

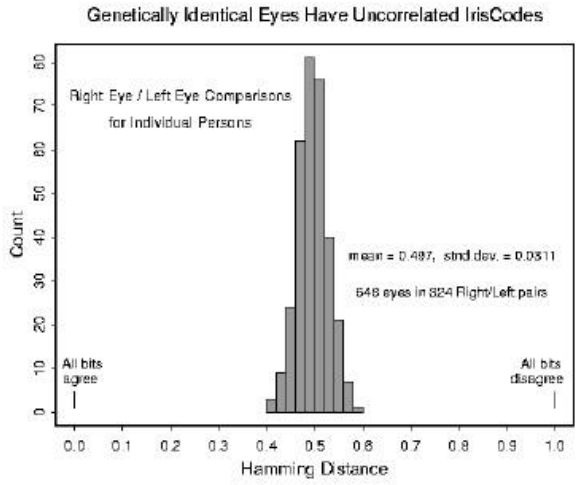
Monozygotic Twins C
(78 year-old men)



Monozygotic twins (3)

Genetically identical eyes have iris patterns that are uncorrelated in detail:

Monozygotic Twins A
(6 year-old boys)



Iris scan

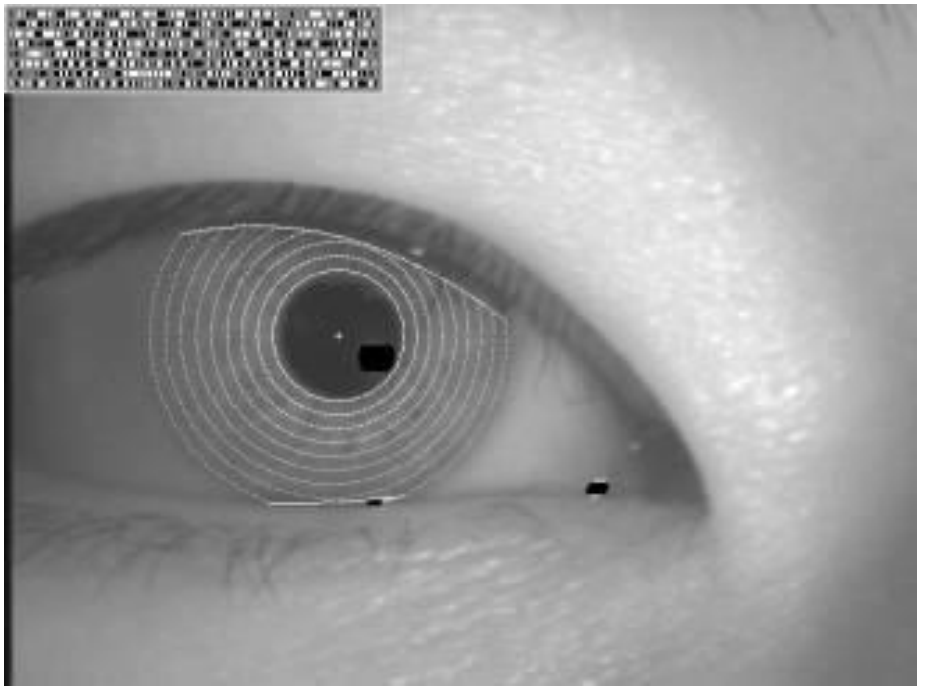
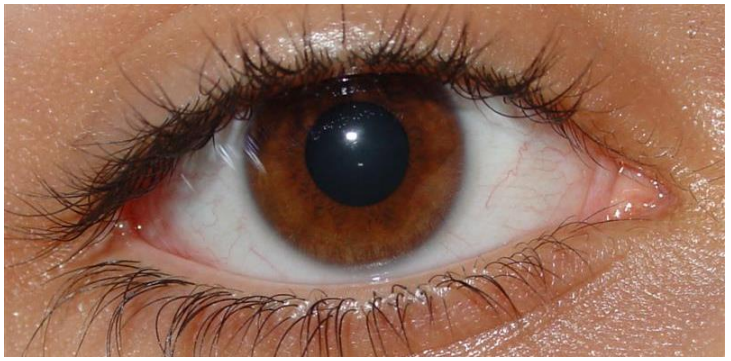
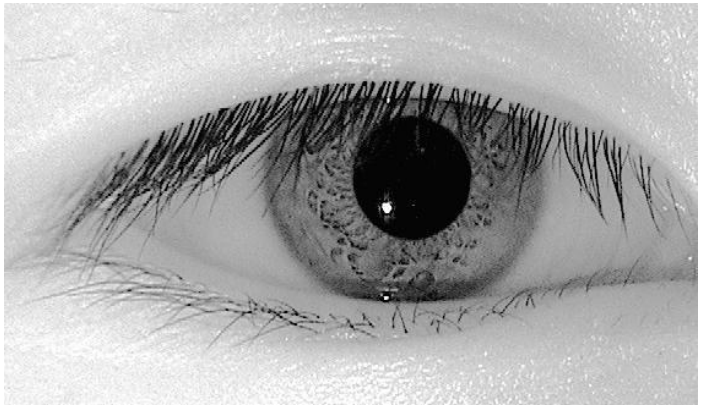


Image size is, say, 256 x 256 = 65536 bytes and the iris code is 8 x 32 = 256 bytes

Visible x Infrared light





Visible light

- Little texture in dark eyes
- causes pupil dilation
- reflection from the ambient light

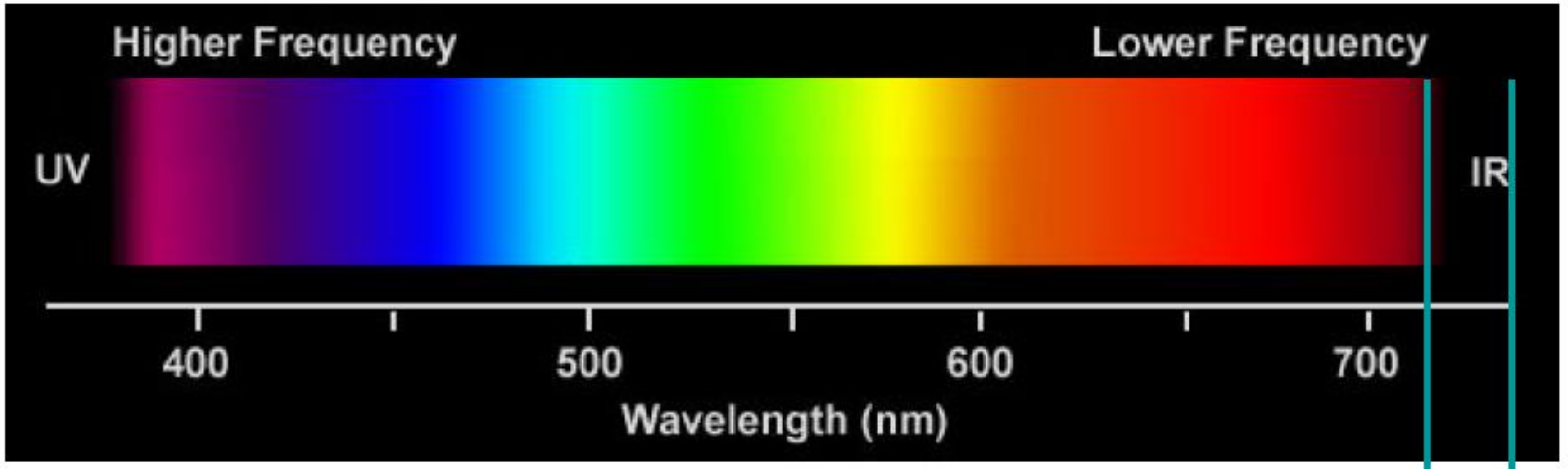
Near infrared (NIR) light

- Similar results for dark and light eyes
- solves the problems above

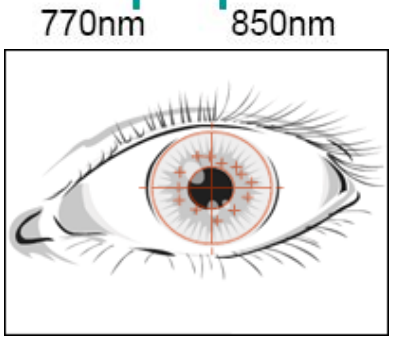
NIR illumination

Consider: absorbed heat depends on wavelength

ANSI certified range for illumination:



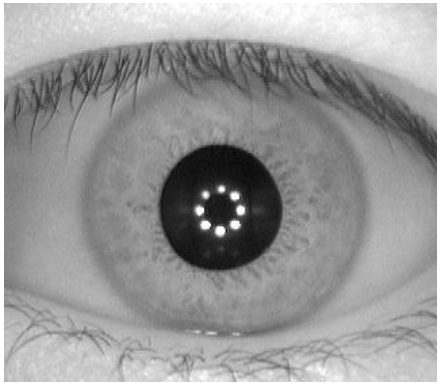
The Panasonic ET-300 illuminators operate just below the visual spectrum. This low power, low frequency light source causes no tissue heating in the anatomy of the eye. For a given power, the higher the frequency, the more tissue heating will occur.



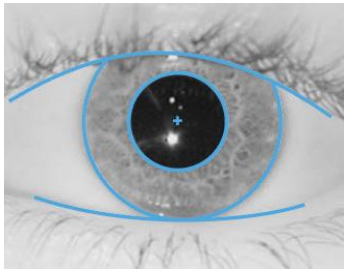
Common IR LEDs: 880nm, 940nm…

Iris image acquisition: requirements

- At least 70 pixels per iris radius (typically 100-140px)
- Monochrome CCD camera 640x480 px with NIR filter usually sufficient
- Getting the detailed view of the iris:
  1. Another wider-angle “face” camera used to steer the Iris camera to the direct spot
  2. User asked to move to desired position

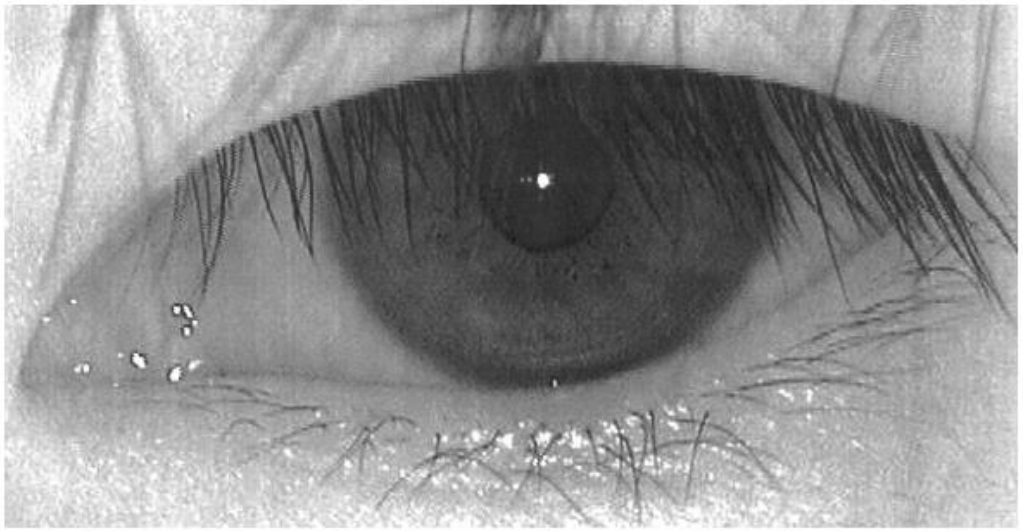


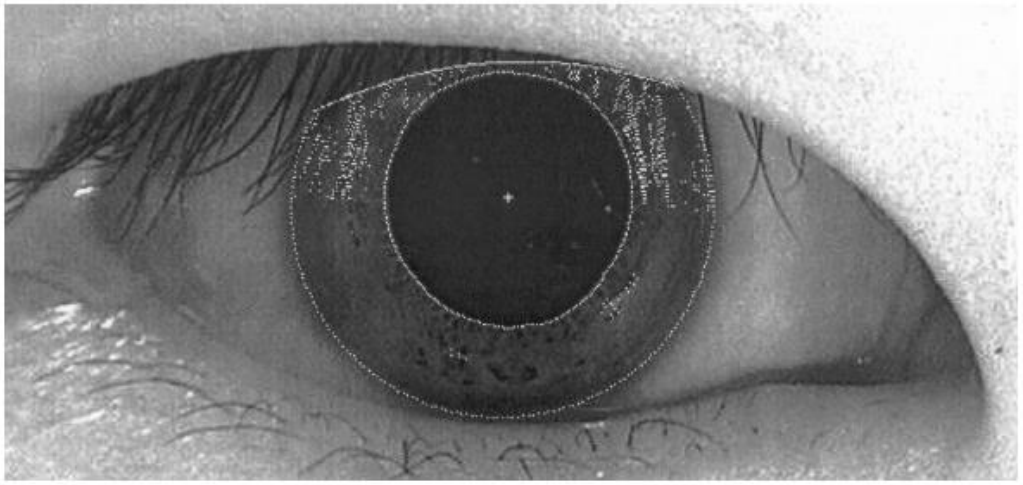
Difficulties in IRIS biom. recog.



- Acquire small target (~1 cm) from (~1 m) distance
- Moving target
- Located behind a curved, wet, reflecting surface
- Curvature of the cornea causes wide-angle reflections
- Obscured by lashes, lenses, reflecting eyeglasses
- Partially occluded by eyelids, often drooping
- Some ethnic groups show less than half of each iris
- Iris deforms non-elastically as pupil changes size
- Illumination should not be visible or bright

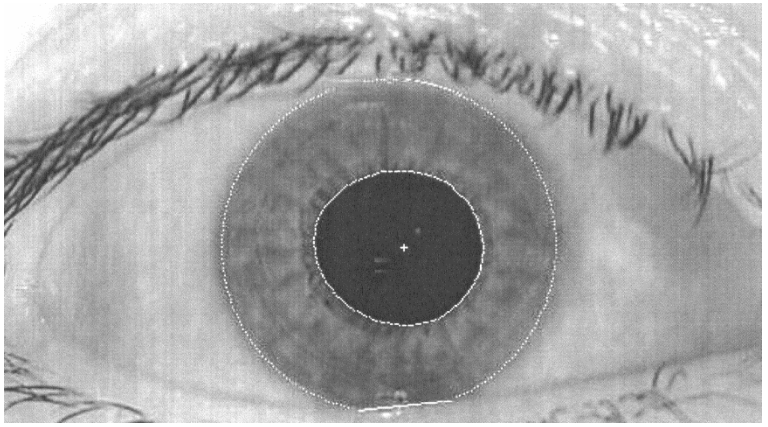
Difficulties: Eyelashes



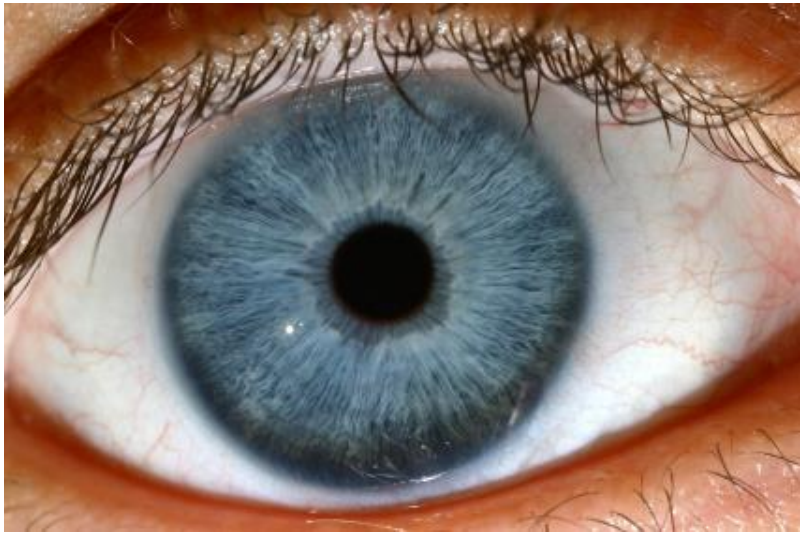


- Iris often partially covered by eyelashes
- Occlusions need to be detected (marked white)

Difficulties: iris shape

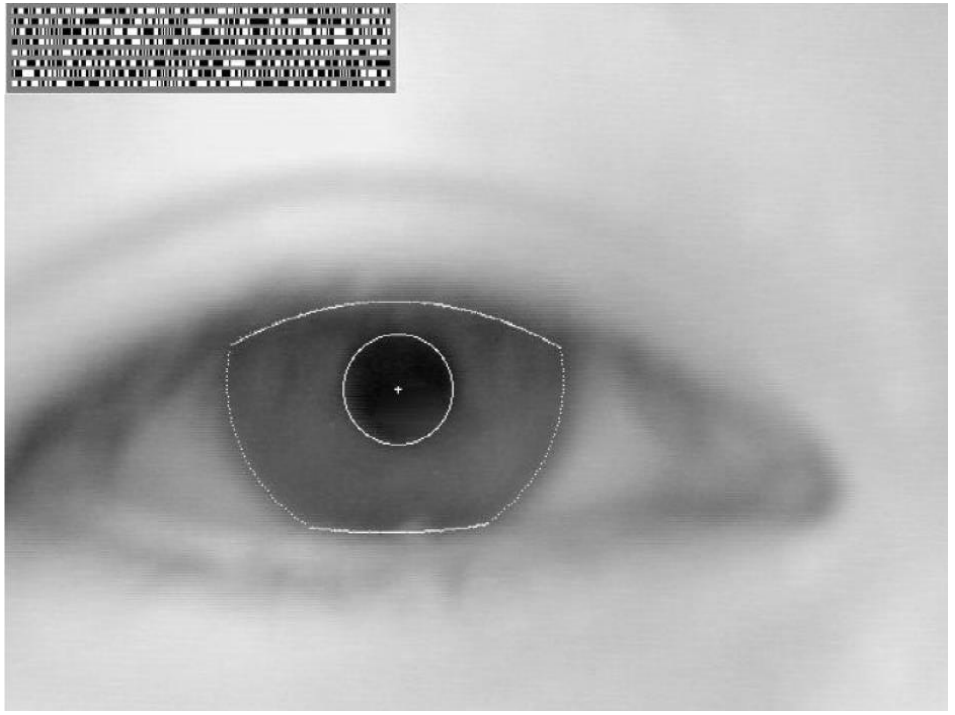


- Pupils often non-circular
- Pupil and iris often non-concentric



Difficulties: defocusing

- It is often hard to achieve perfect focus, especially at longer distance or with moving subject
- Motion blur may be an issue too
- Iris code from such image: such as from random noise



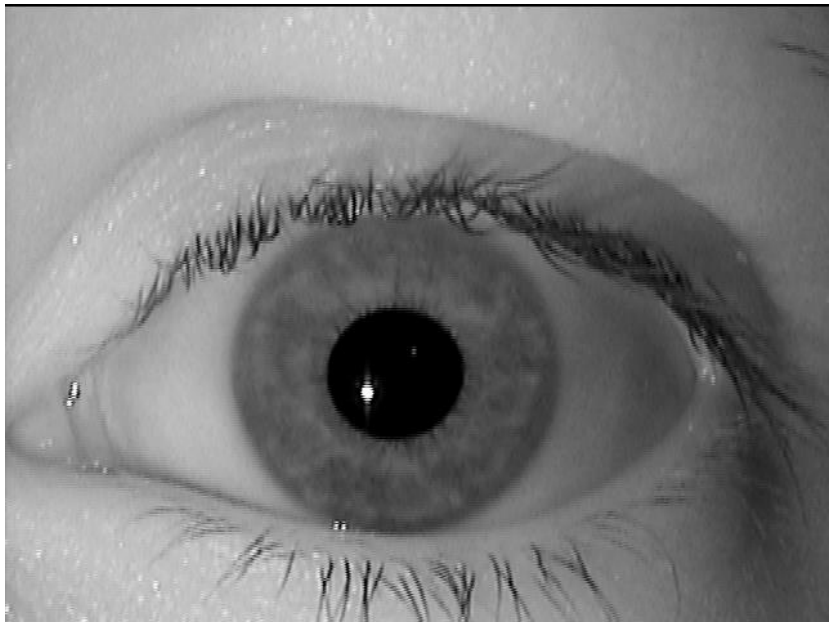
Attacks: fake iris

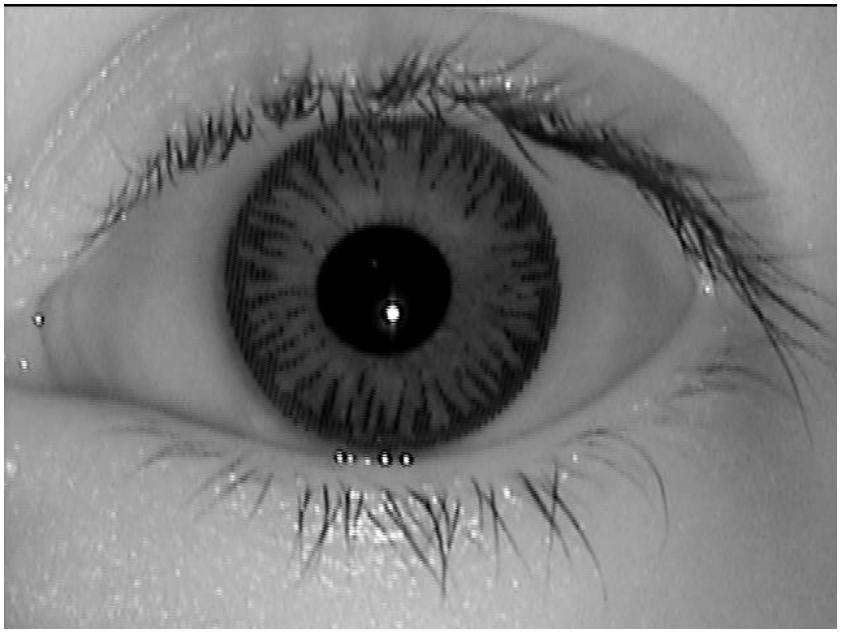
- Presentation of fake (printed on paper or contact lens, LCD) iris to the camera
- Problem for systems without surveillance (e.g. access systems)

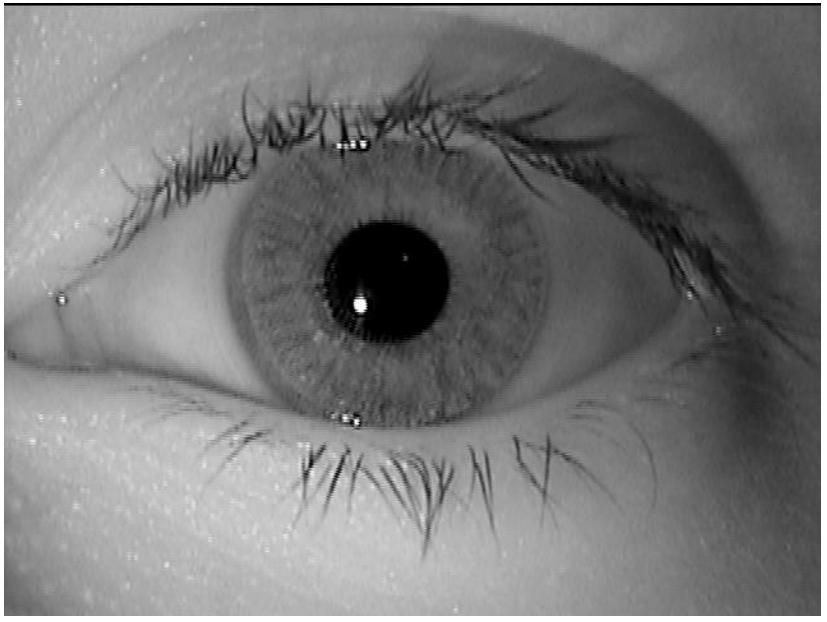
:)

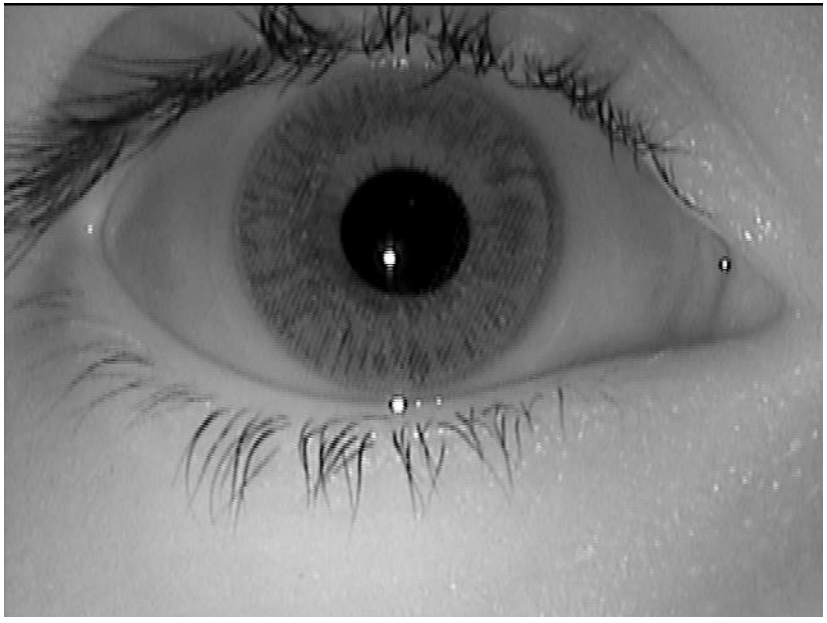
cosmetic contact lenses

Contact lenses

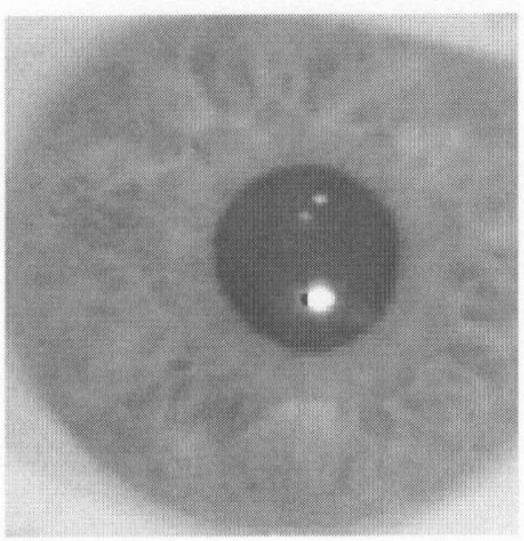




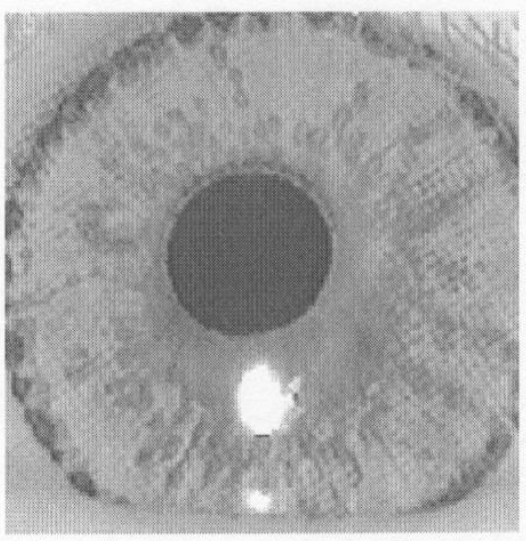




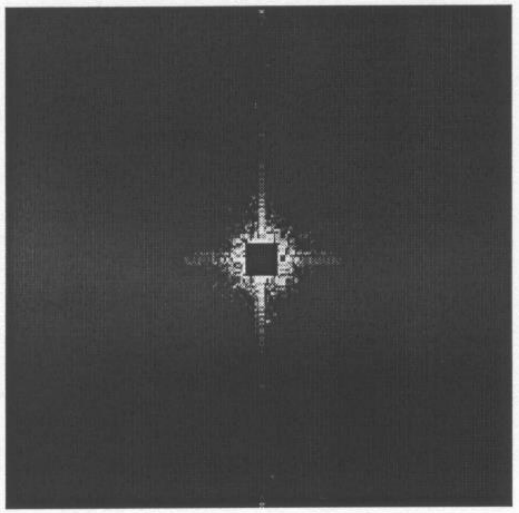
Fake iris attack solutions



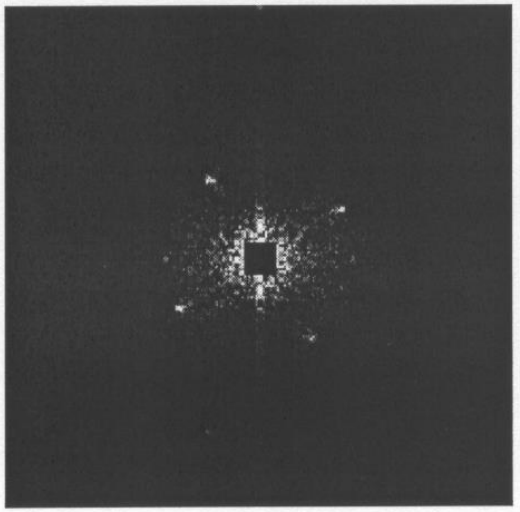
Natural Iris



Fake Iris printed on a contact lens



2D Fourier spectrum of natural Iris

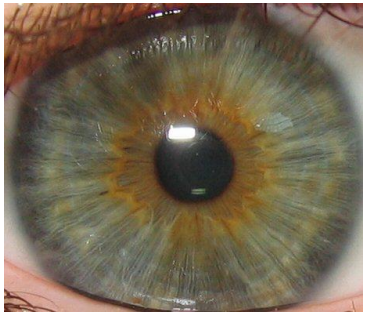


2D Fourier spectrum of fake Iris

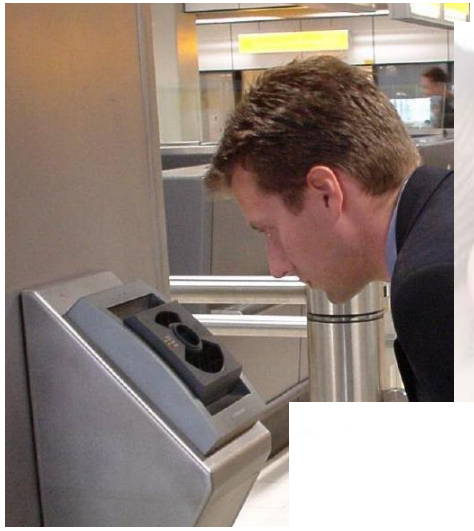
- Checking for pupil-dilation effect (swithing visible light intensity)
- FFT transform of the iris image shows artefacts caused by printing halftone patterns
- (frequency: radial, direction:angle)

Fake iris attack solutions (2)

- Iris displayed on an LCD sceen
  - Observation of temporal properties of the image (intensity peaks in LCD image)
- Identification of reflections
- Verification of pupil dilation reflex
  - pupil diameter measured for different light intensities



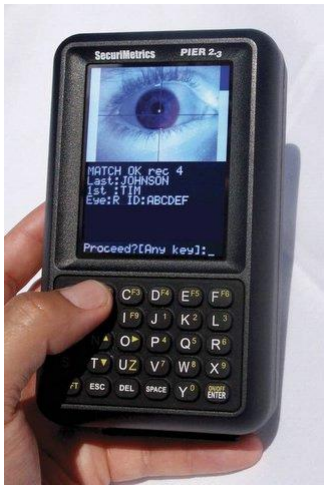
Iris scan: devices



Iris capturing devices

Princeton identity
Access200

IrisGuard ATM



PIER 2.3, Hand-held,
SecuriMetricsInc.,

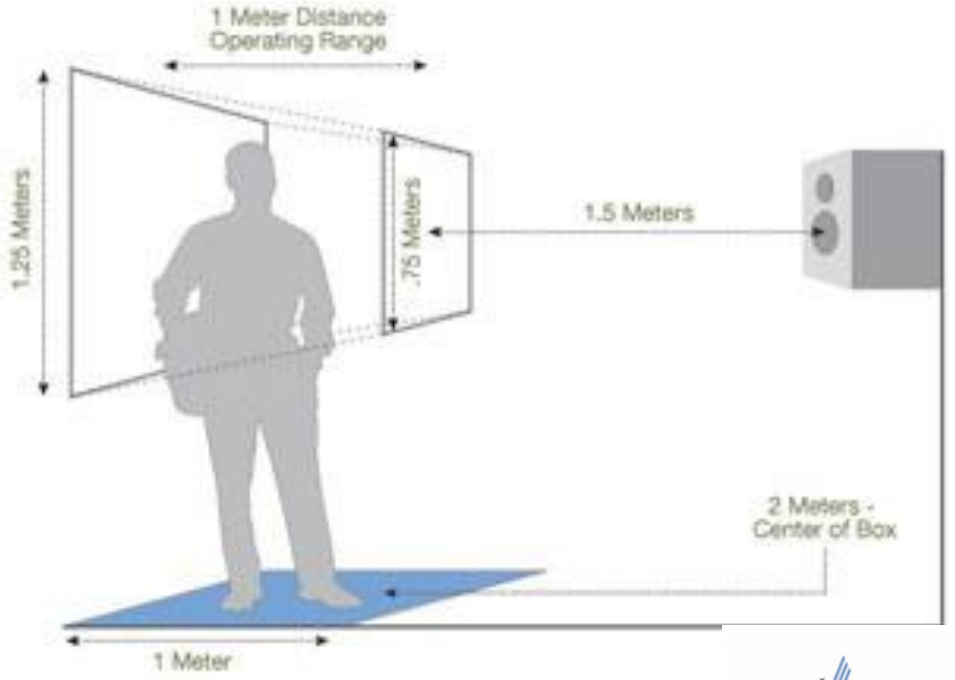
IriTech iriShield 2120

IrisGuard IG/H100

wall mounted
Entry access control
Panasonic ET300

https://www.irisguard.com/technology/products/

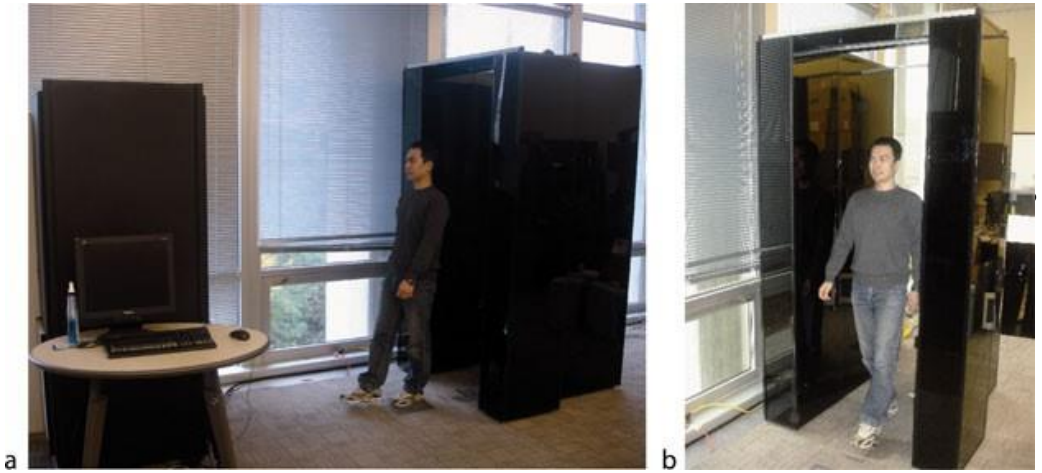
Iris capturing at long distance



- Distance 2m
- Adaptive Optics technology automatically finds the eye, then locks in with its closed-loop control subsystem to capture a series of high-quality iris images.
- Subjects merely need to glance at the target for a short period of time once inside the capture zone.

The instruction set is extraordinarily simple: step into the capture volume, look at theimager, and open your eyes.

Reduced need of subjects cooperation



Iris on the move (Sarnoff Int.)

Iris on the move

SRI International
SARNOFF

Now: Princeton identity

NEC walkthrough terminal

- Capturing IRIS images while the subject is walking through a gate
- The subject only has to look straight at given point (the camera)
- 3m distance, works through sunglasses (!), 30 people/min
- supports iris code calculation
- stand-alone (including enrollment)
- Discontinued?

Applications (current and future)

- **computer login**: the iris as a living password
- **national border** controls: the iris as a living passport
- secure access to bank **cash machine** accounts
- ticket-less, **document-free, air travel**
- premises **access control** (home, office, laboratory, etc)
- driving licenses, and other **personal certificates**
- entitlements and benefits authentication
- forensics; birth certificates; tracing **missing or wanted persons**
- **credit-card** authentication
- automobile ignition and unlocking; **anti-theft devices**
- anti-terrorism (e.g. **security screening** at airports)
- secure **financial transactions** (electronic commerce, banking)
- **Internet security**; control of access to privileged information
- "**Biometric-Key Cryptography**" for encrypting/decrypting messages
- any existing use of keys, cards, PINs, or passwords

Usage of IRIS at Airports

- ‘Iris as Passport’: Expedited immigration clearance for arriving passengers
  - Amsterdam Schiphol, Frankfurt, 10 UK airport terminals and 8 Canadian airports in 2004
- Expedited processing and check-in of departing passengers
  - Tokyo Narita (1’000 frequent travelers)
- Airline crew facility access and expedited security clearance
  - Charlotte Douglas Airport (1’200 transactions per day)
- Airport employee access to tarmac and other restricted areas (80 access control points)
  - New York JFK, Amsterdam Schiphol (72’000 airport employees)
- ‘WatchList’ screening of all arriving passengers (505’000 expellees in WatchList
  - 7 airports

United Arab Emirates

- Iris recognition system
- Fully operational since April 2003
- 36 land, air and sea ports
- 12,000 passengers each day
- 1 central database
  - Watchlistof expelled persons
  - Fully networked
  - Enrolment centres: prisons and deportation centres
  - More than 1 million enrolments (150+ nationalities)
  - Exhaustive search takes <2 seconds
- 12 billion comparisons each day (12,000 passengers against 1 million enrolments)
- About 330,000 persons caught since launch in 2005

IrisGuard Incorporated

India: National ID system

- UIDAI (Unique Identification Authority in India): Adhaar ID card (unique citizen system) https://uidai.gov.in/, Launched: 2009
- Biometric verification : fingerprint (fingers) / Iris / Face photo
- More than 1.2B+ users enrolled (99% of adult population in India) – voluntary enrollment, required to access social services
- Biometrics can be locked to prevent misuse
- Conroversy: can private companies require the adhaar number https://time.com/5409604/india-aadhaar-supreme-court/
- …leprosy sufferers with no fingers or eyes having their state benefits cancelled because fingerprints and iris scans are mandator

United Arab Emirates

Usage in the UK

- UK's *IRIS (Iris Recognition Immigration System)* replaces passport control
- Available at several airports in the UK between 2004-2013
- Automatic counters for registered travellers
- Over 1 000 000 registered frequent flyers
- No ID – one-to-all identification scheme
- Superseeded by biometric passport

a

b

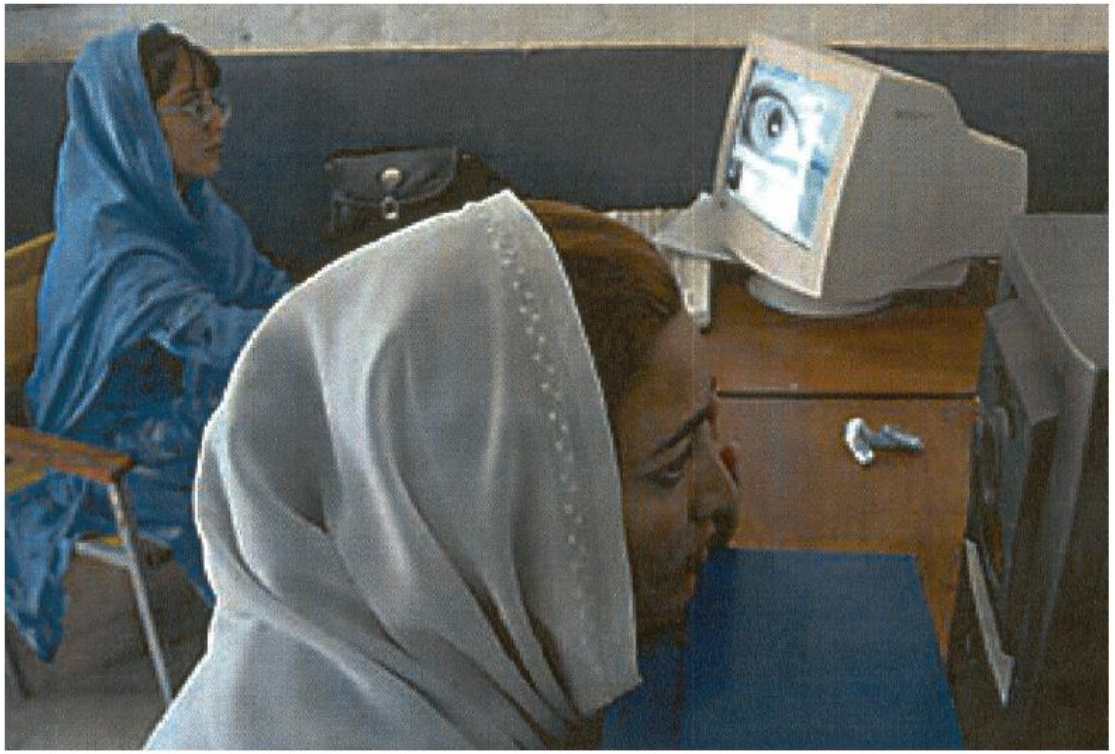
The Netherlands

- Similar to the UK system (frequent flyers' programme to avoid queues)
- Paid service

Access systems

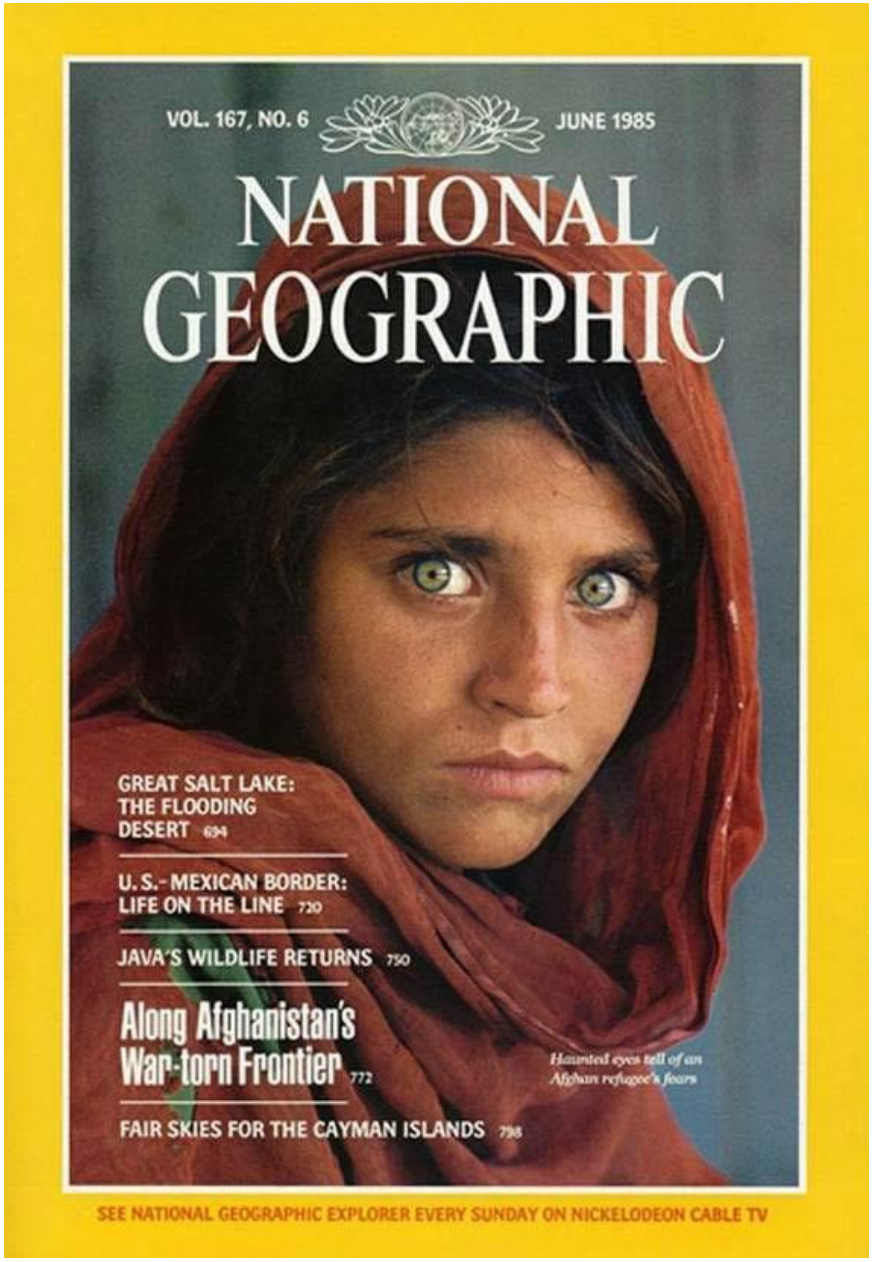
Residential Access to Condominium (and Lift Calling), Tokyo.

IRIS in humanitary projects



Takhtabaig Voluntary Repatriation Centre, Pakistan-Afghan border. United Nations (UN) cash grants for returnees are administered by Iris identification

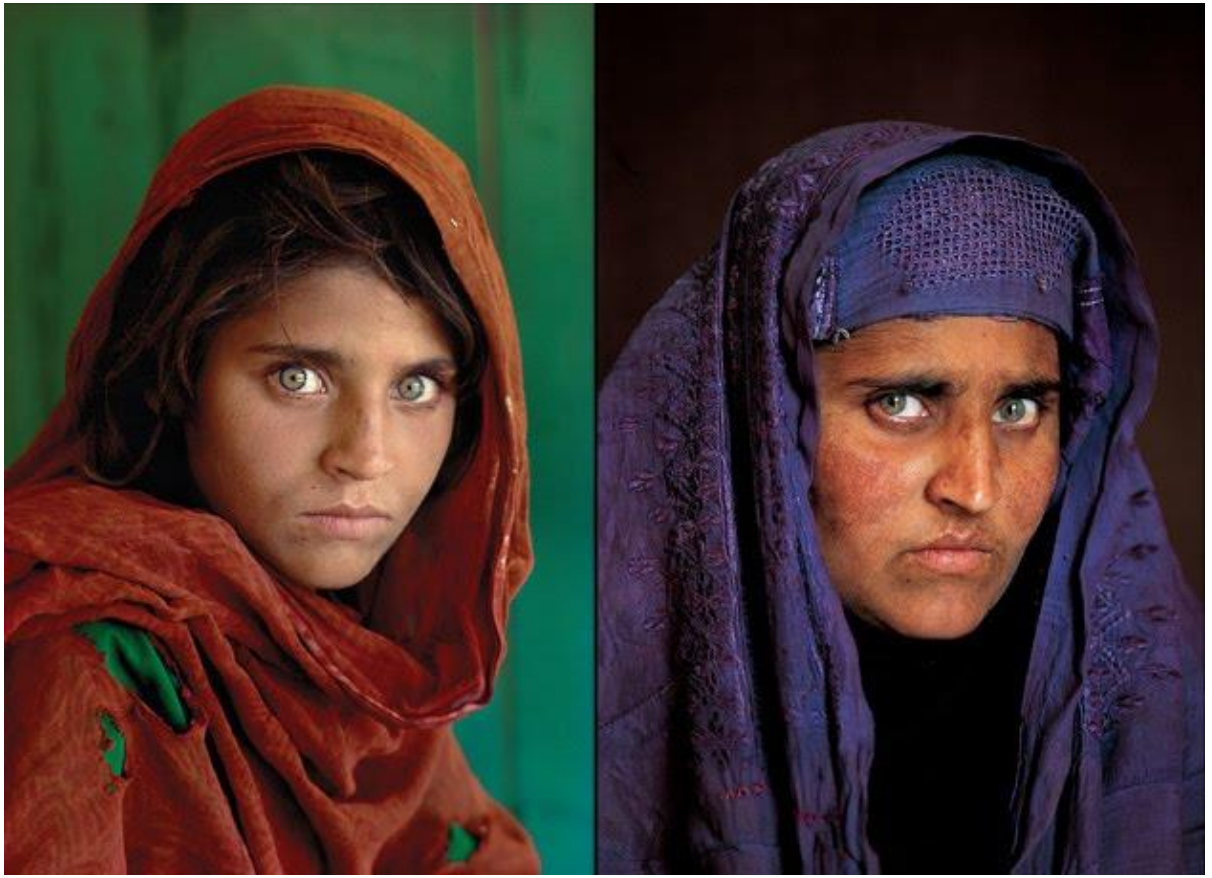
Motivation: NG story



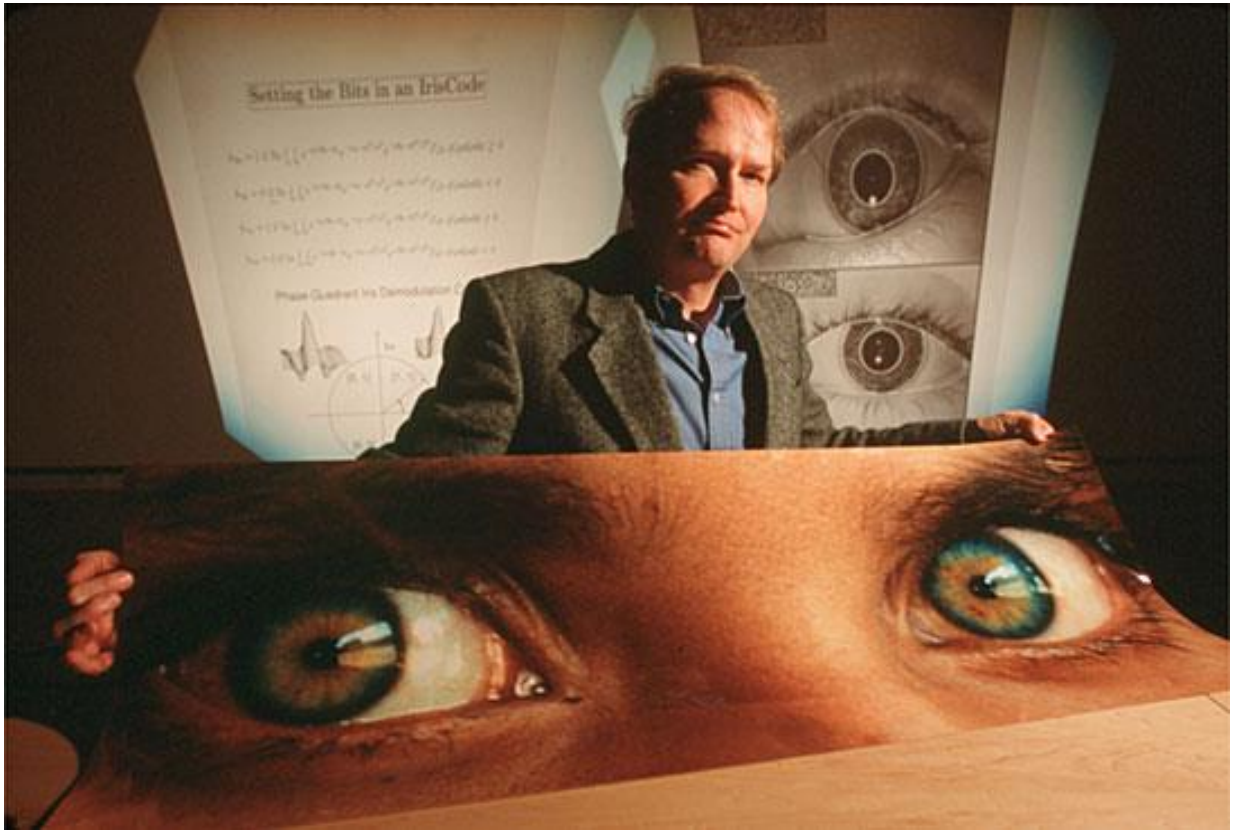
- National Geograpic cover story: a girl refugee in Pakistanian refugee camp after her city in Afghanistan was bombed by USSR army.
- One of the most recognized pictures in the history of NG ("Afghan girl")
- Photographed by S. McCurry in 1984

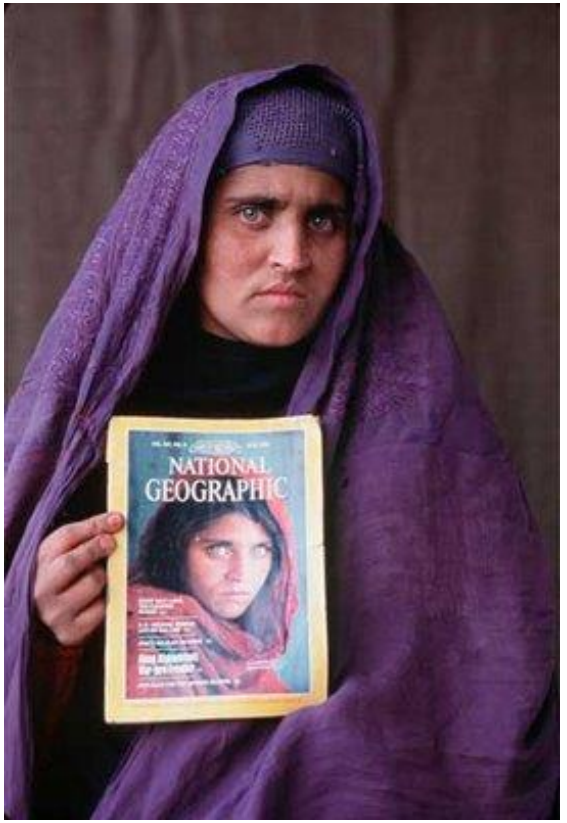
“Afghan girl” story continued

- McCurry tried to located the girl 17 years later in 2001
- Several women claimed they were the girl in the picture
- Several men claimed the girl was their wife...
- Iris recognition matched Sharbat Gula to the original picture



John Daugman





Core Technology Patent:"Biometric Personal Identification System Based on Iris Analysis", U.S. Patent No. 5 291 560 issued March 1, 1994 (J. Daugman)

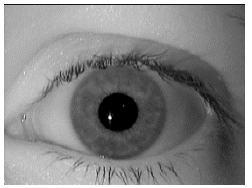
Key messages

- Iris: **stable** and very **individual** property
- Highly suitable for biometric identification/verification
- Iris **image** rather **difficult to capture** (focusing, motion-blur, lighting, reflections, pupil dilation...)
- Iris recognition systems in operation in **large-scale** border and **access control systems**

Overview of the next lecture

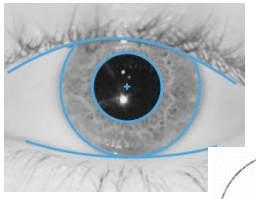
- Iris recognition process (Basic J. Daugmann approach and some modalities)

IN

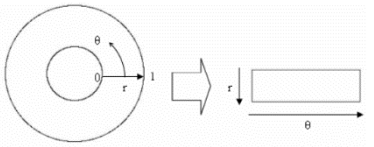


iris image

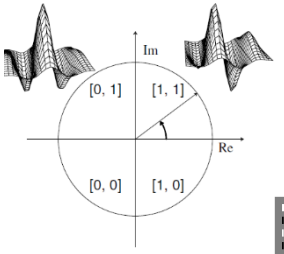
- Iris segmentation



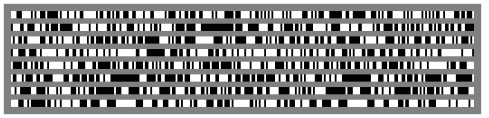
- Unwrapping



- Feature extraction

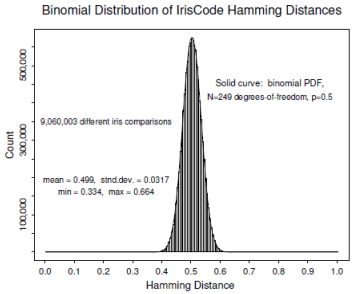


- Encoding



- Comparison

OUT



result of iris code comparison

Thank you for your attention