

A close-up photograph of a human eye with a green iris. The iris has a complex, fibrous texture with a dark central pupil. The surrounding sclera is white, and the eyelids are a reddish-brown color. The image is used as a background for a presentation slide.

IRIS recognition

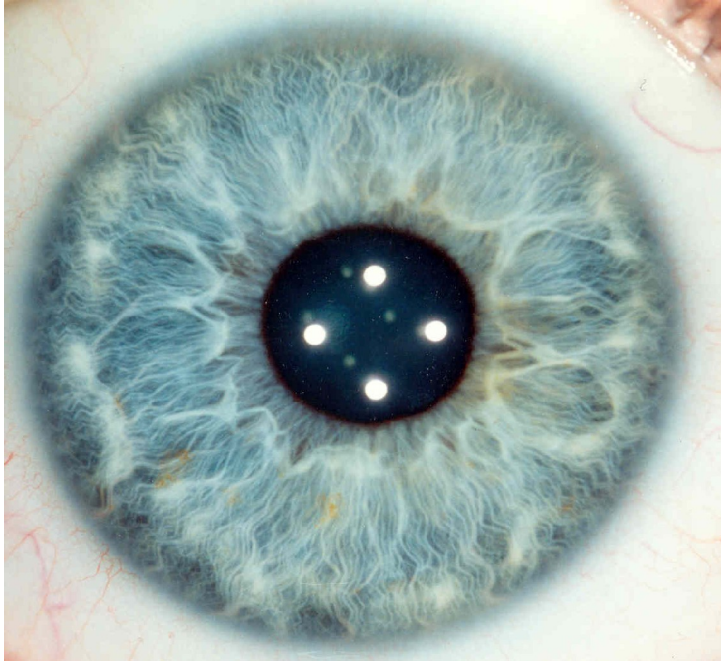
Eduard Bakštein,

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15.11.2011

acknowledgement: **Andrzej Drygajlo, EPFL Switzerland**

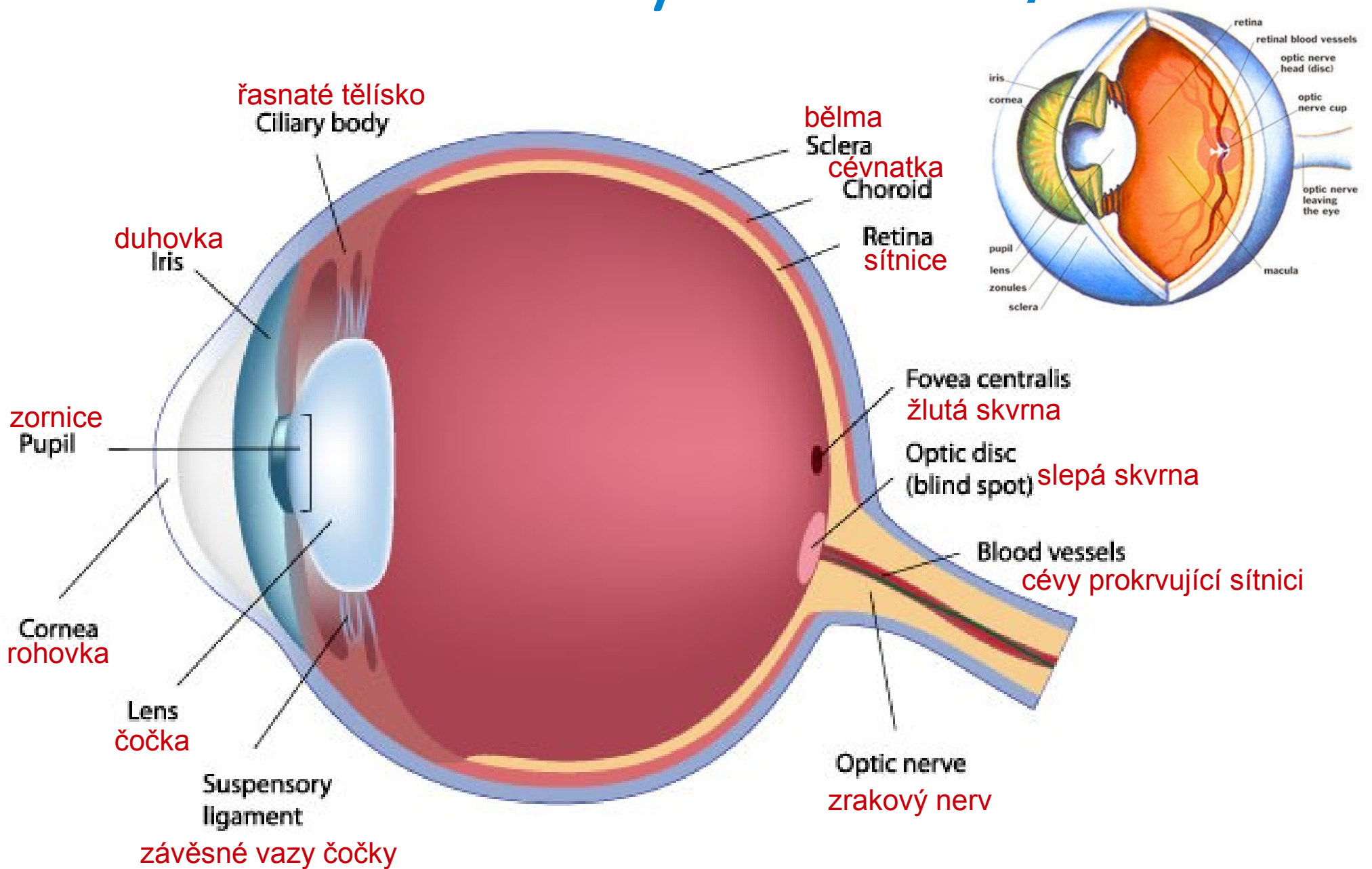
Outline



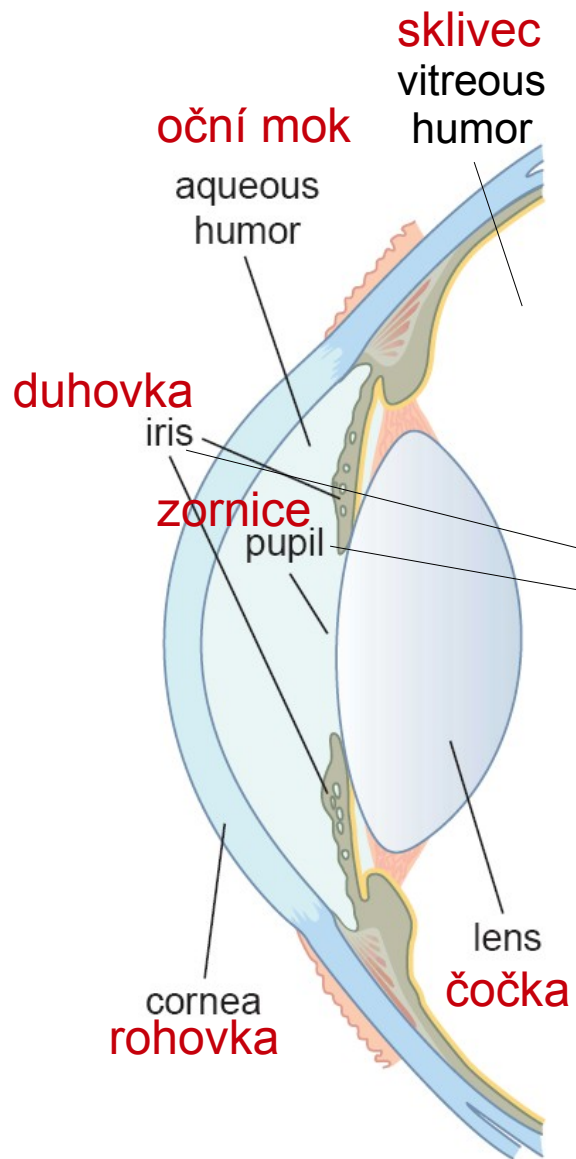
- Introduction
- Iris basics
- History + iridology
- Iris in biometry
- Properties of the Iris
- Sensing
- Applications

Next time: Processing

Human eye anatomy



The IRIS (Basics)



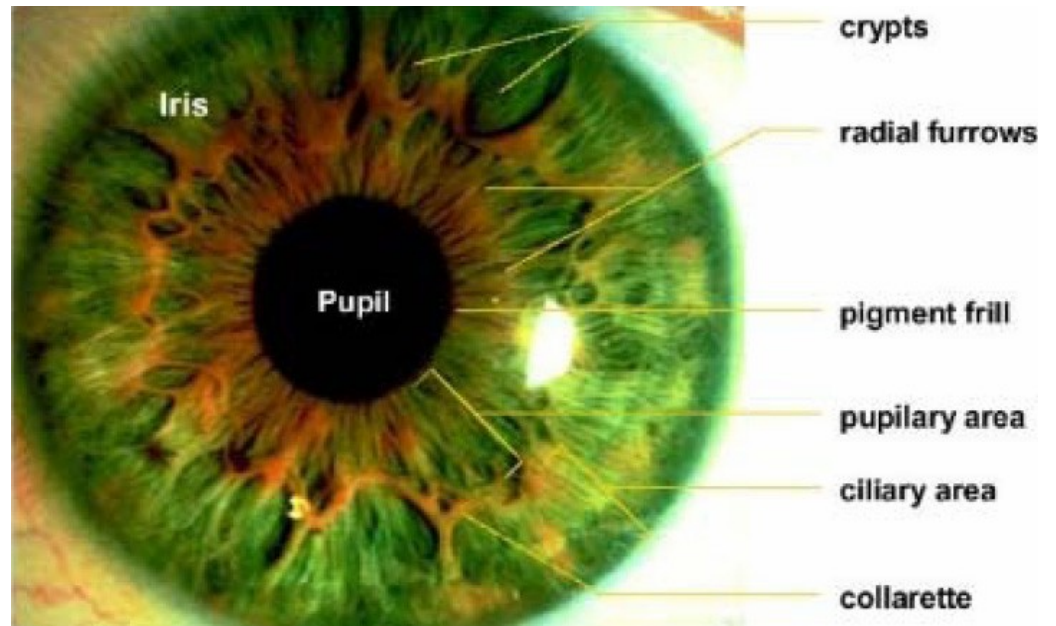
sclera
bělma

The IRIS (Basics II)



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

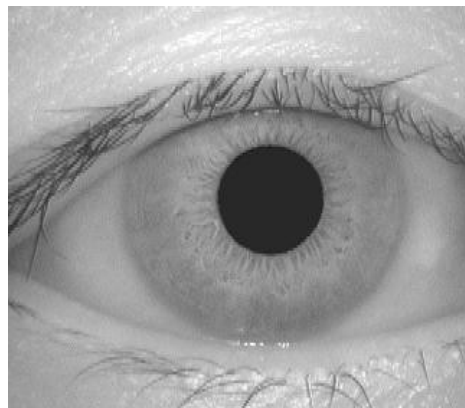
Distinctive features:
furrows, ridges, crypts,
rings, corona, freckles etc.



Not to be confused with retinal scan

Iris

- Colored ring-shaped organ in the front part of the eye
- Encoding iris patterns
- Scanning: camera (infrared)
- Scanning distance: cm to ~3m
- Time needed: ~1s

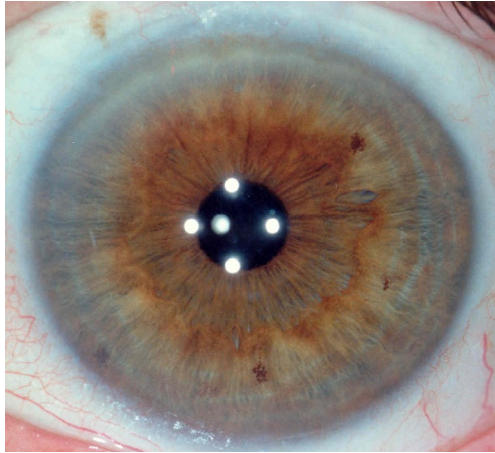


Retina

- blood vessels at the back of the eye
- Vessel shapes etc
- Cannot be faked
- Decomposes rapidly after death
- Scanning: coherent light beam
- Scanning distance: 0m
- Time needed: ~10-15s



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]

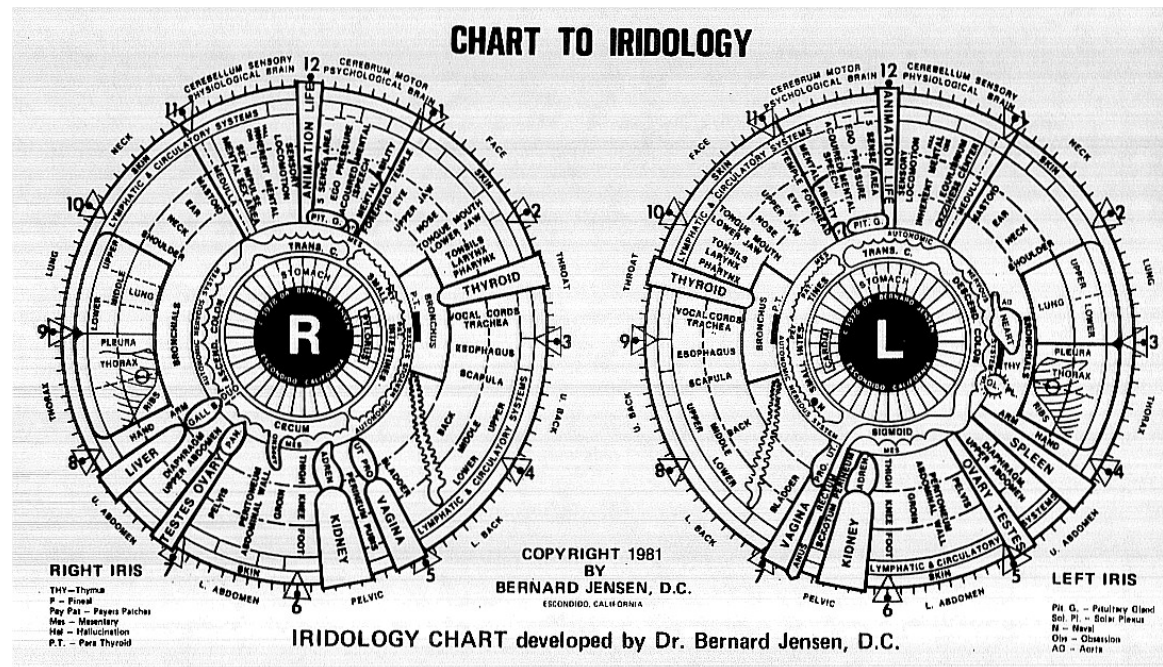
source: <http://ethymonline.com>

History of Iris recognition

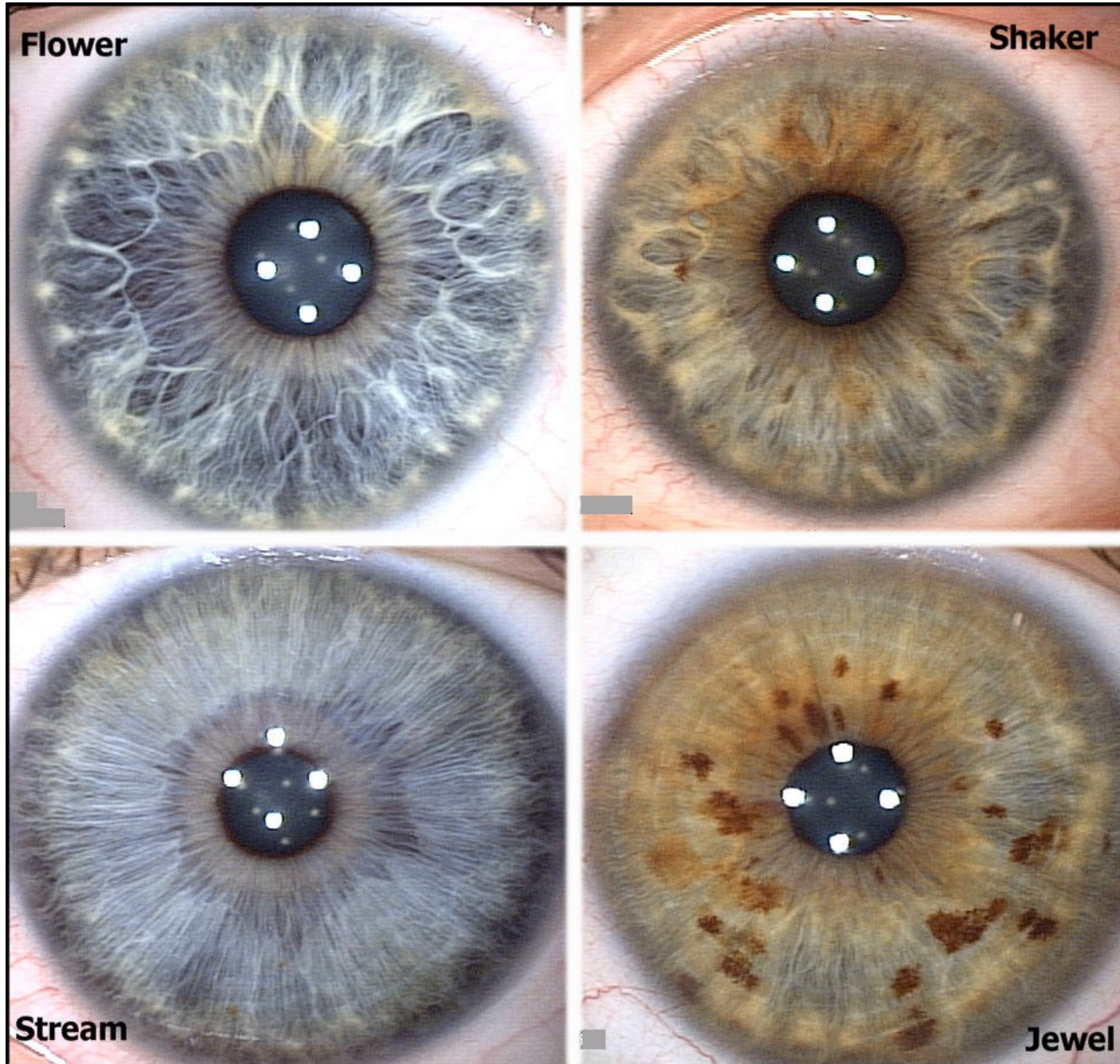
- **Ancient civilizations** - Ancient Egypt (~3000 B.C.), Ancient China Chaldea in Babylonia (~700 B.C.), Ancient Greece (~300 B.C.) - divination from iris
- **19th century** - Ignaz von Peczely: iridology
- **1885** - Alphonse Bertillon: idea of using iris for personal identification (color and pattern 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:

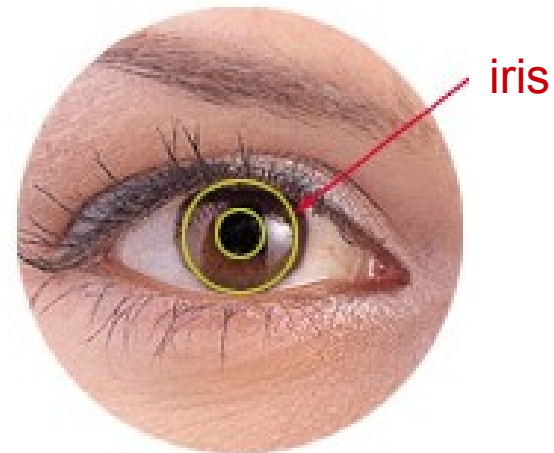
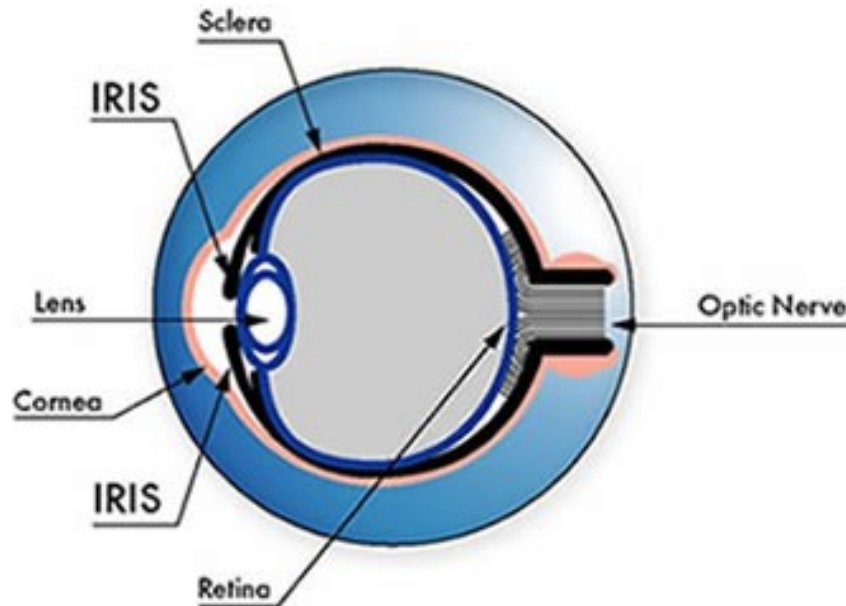
- Eye = “window to the soul”
- “Modern medicine neglects true roots of medical problems”

Medical experts:

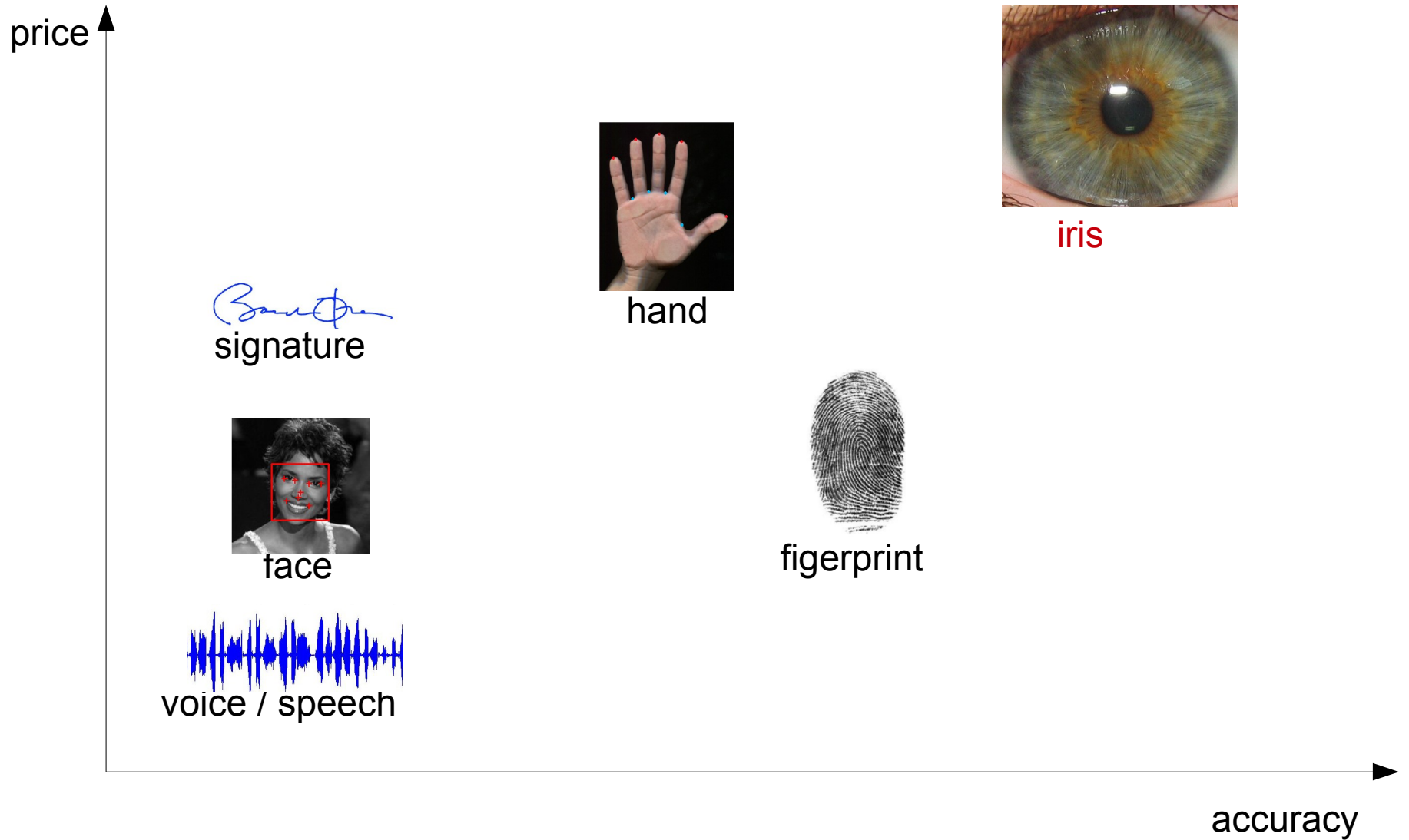
- Iridology = medical fraud
- Supported by scientific tests
 - Berggren, L. (1985), “Iridology: A critical review”, *Acta Ophthalmologica*, 63(1): 1-8

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 palms and geometry, and 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

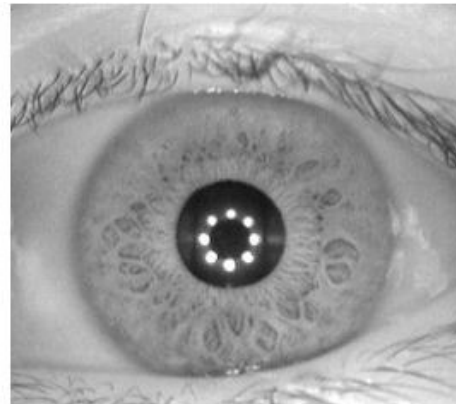
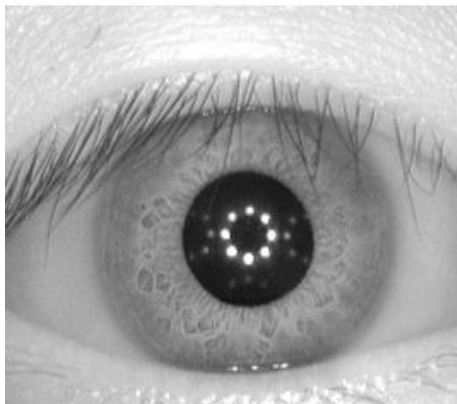
Phenotype - all observable properties of a living organism.

- fingerprints, iris (except eye color)

Phenotype = genotype + environment

Every biometric feature somewhere inbetween

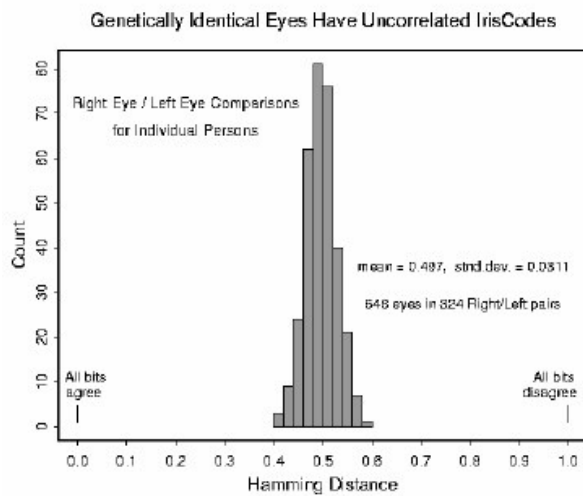
Iris pattern is a phenotypic feature



Proof: monozygotic twins

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

Monozygotic Twins B
(18 year-old women)



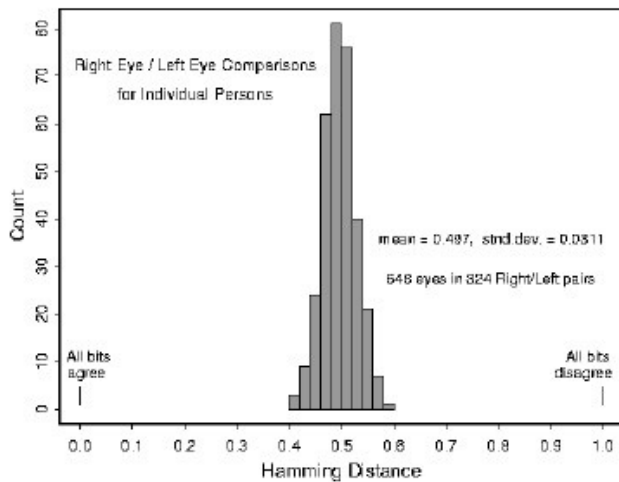
Monozygotic twins (2)

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

Monozygotic Twins C
(78 year-old men)



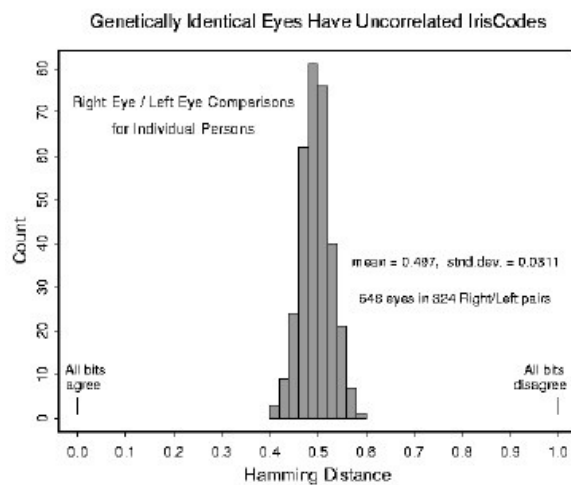
Genetically Identical Eyes Have Uncorrelated IrisCodes



Monozygotic twins (3)

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

Monozygotic Twins A
(6 year-old boys)



Advantages of the iris in biometry

- Iris patterns possess a high degree of randomness and uniqueness set by combinatorial complexity
- Encoding and matching are reliable and fast
- Iris codes very compact to store (hundreds of bytes)
- Changing pupil size can confirm it is a real iris



iris code

Iris scan

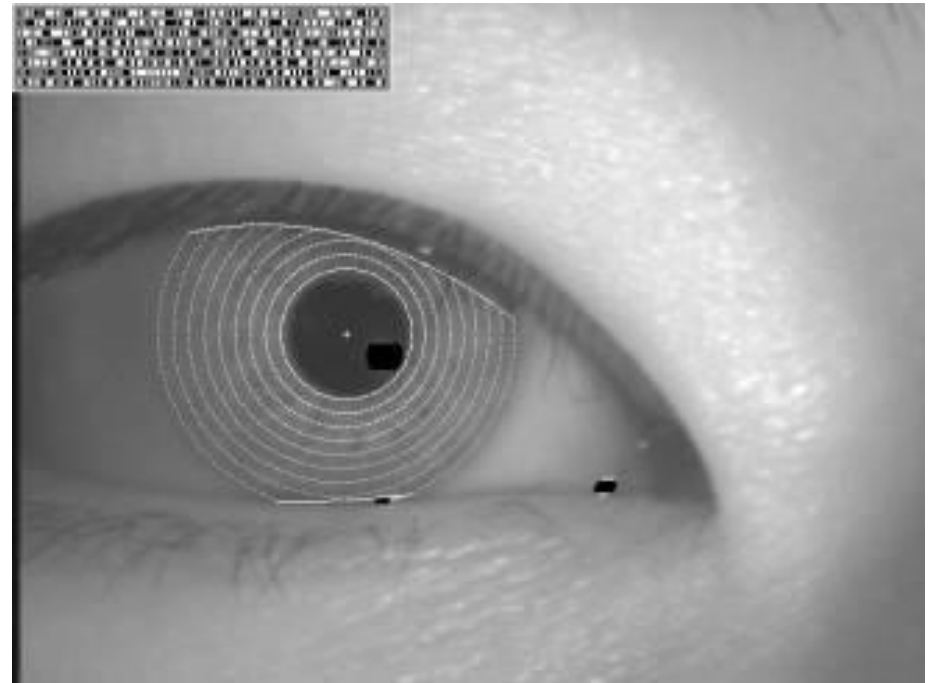
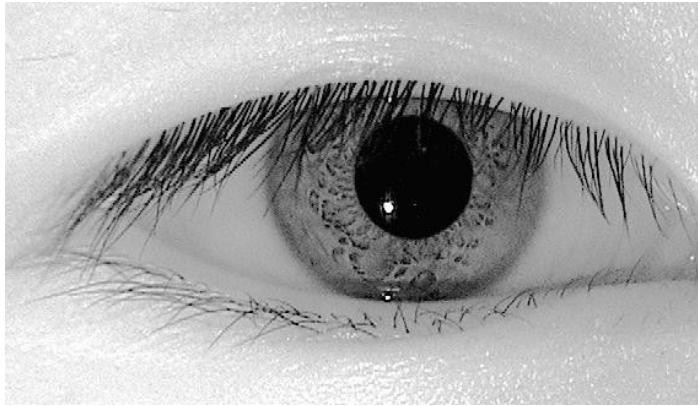
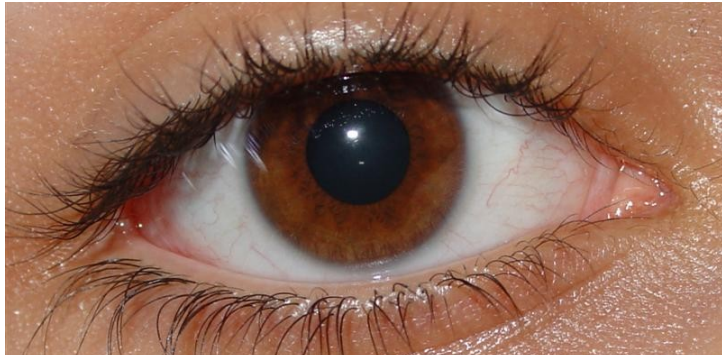


Image size is, say, $256 \times 256 = 65536$ bytes and the iris code is $8 \times 32 = 256$ bytes

Visible x Infrared light



Visible light

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

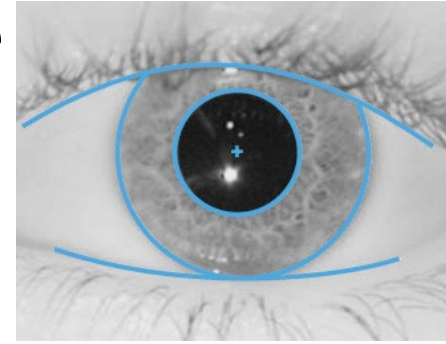
Near infrared (NIR) light



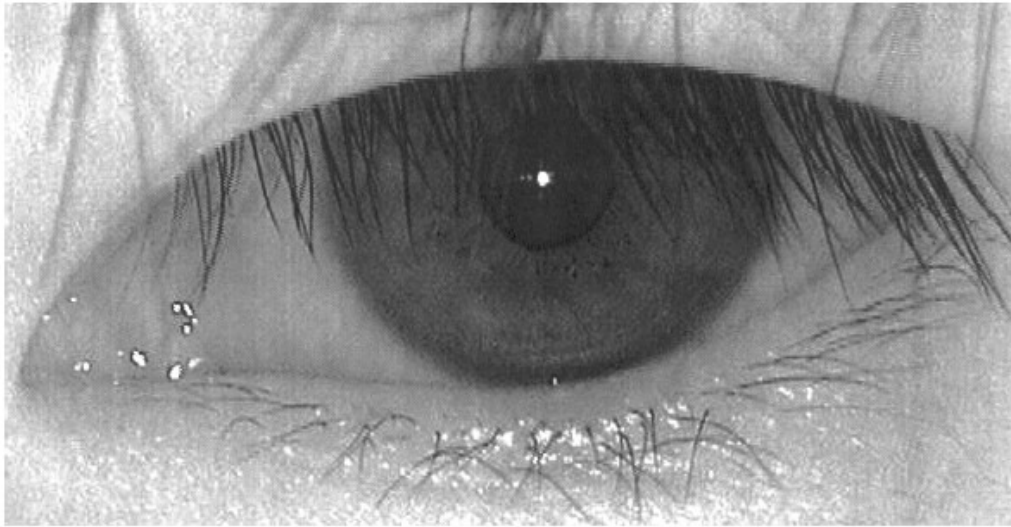
- Similar results for dark and light eyes
- solves the problems above

Difficulties in IRIS biom. recog.

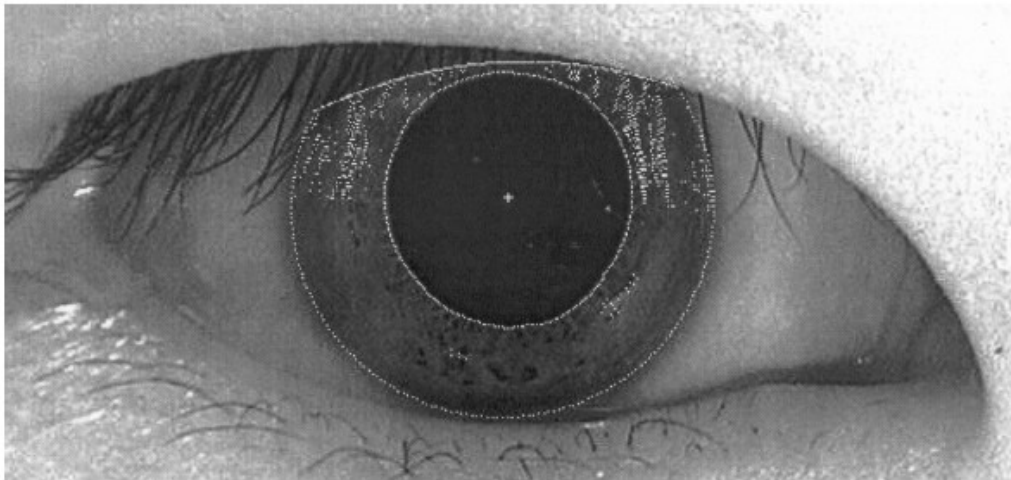
- Small target(1 cm) to acquire from(1 m) distance
- Moving target
- Located behind a curved, wet, reflecting surface
- Curvature of the cornea causes wide-angle reflections
- Obscured by lashes, lenses, reflecting eyeglasses
- Partially occluded by eyelids, often drooping
- Some ethnic groups show less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



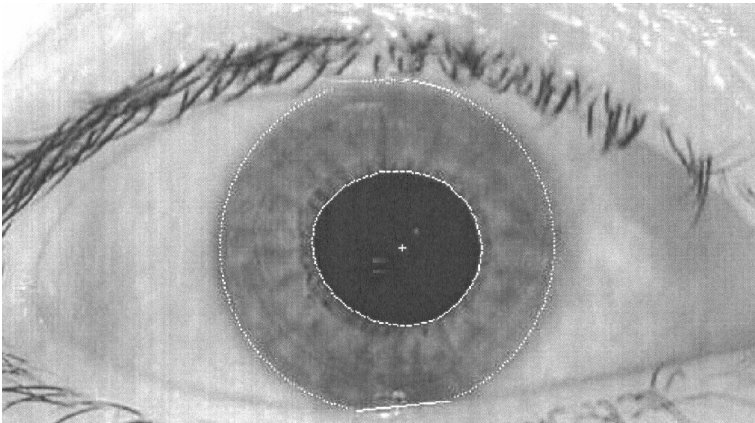
Difficulties: Eyelashes



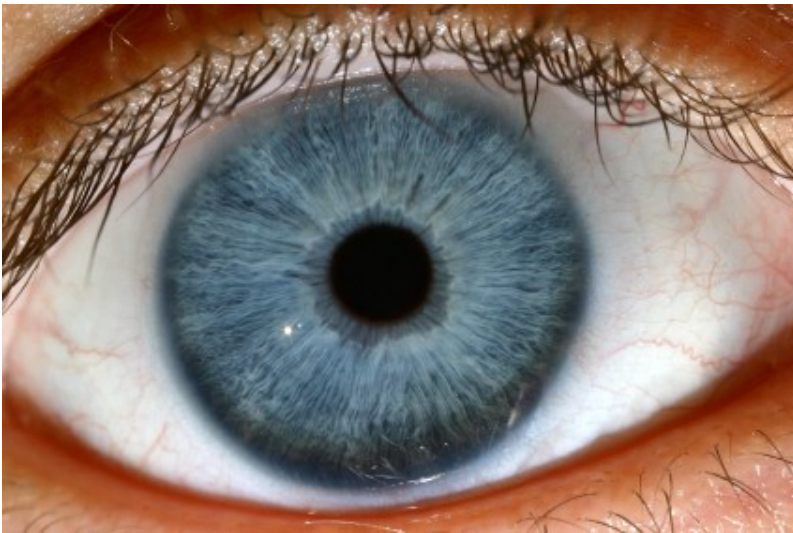
- Iris often partially covered by eyelashes
- Occlusions need to be detected (marked white)



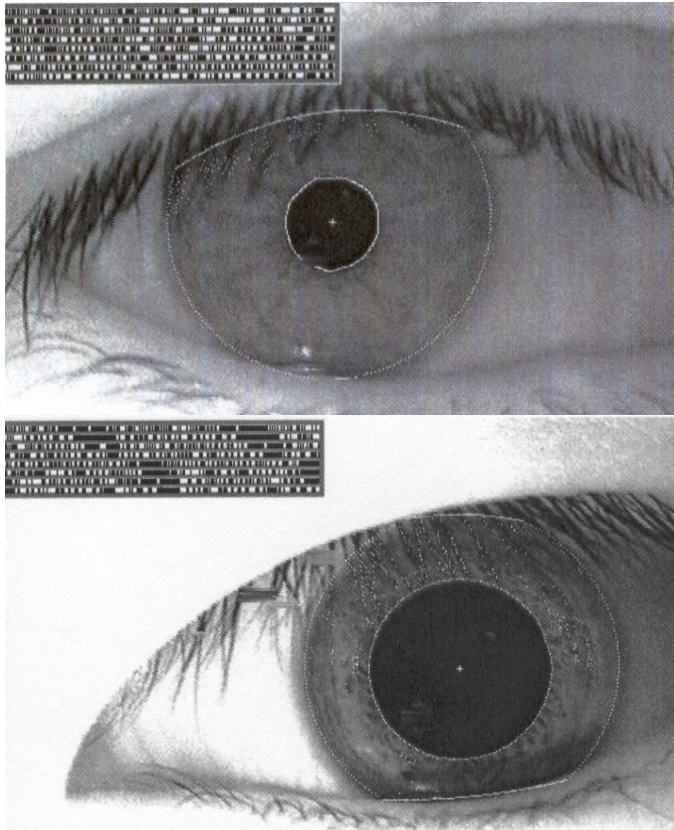
Difficulties: iris shape



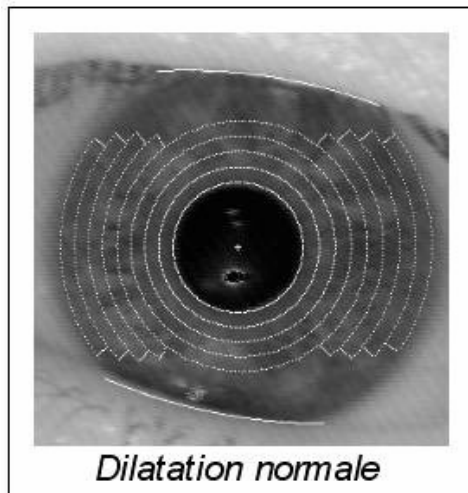
- Pupils often non-circular
- Pupil and iris often non-concentric



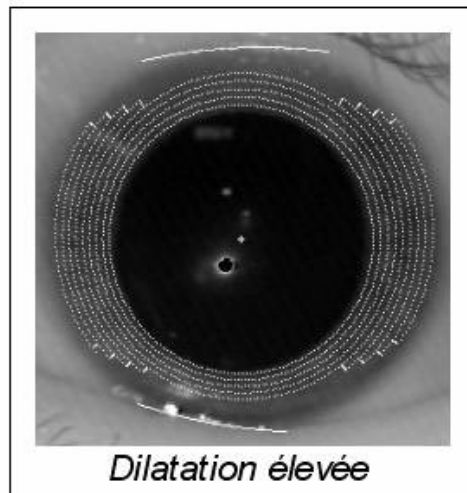
Difficulties: invariant mapping



- Iris code mapping must be invariant to:
 - shift (position in the image)
 - distance
 - magnification
 - pupillary dilation
 - rotation (head tilt)



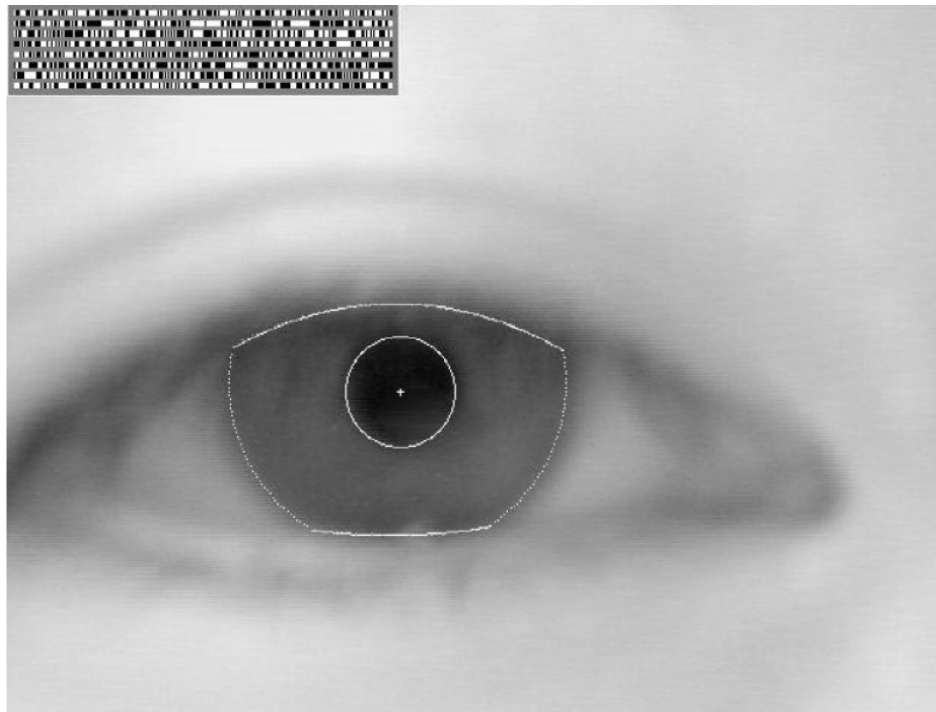
Dilatation normale



Dilatation élevée

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



Difficulties: Fake iris attack



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

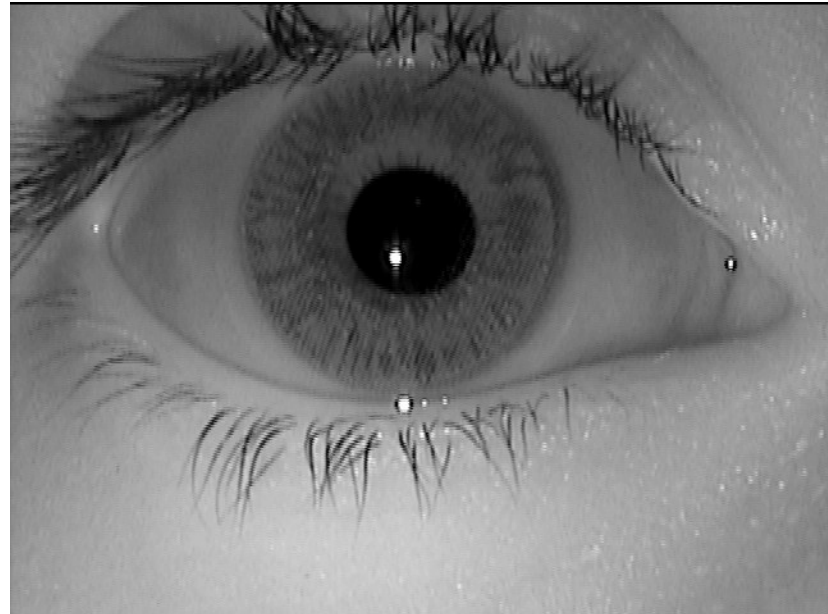
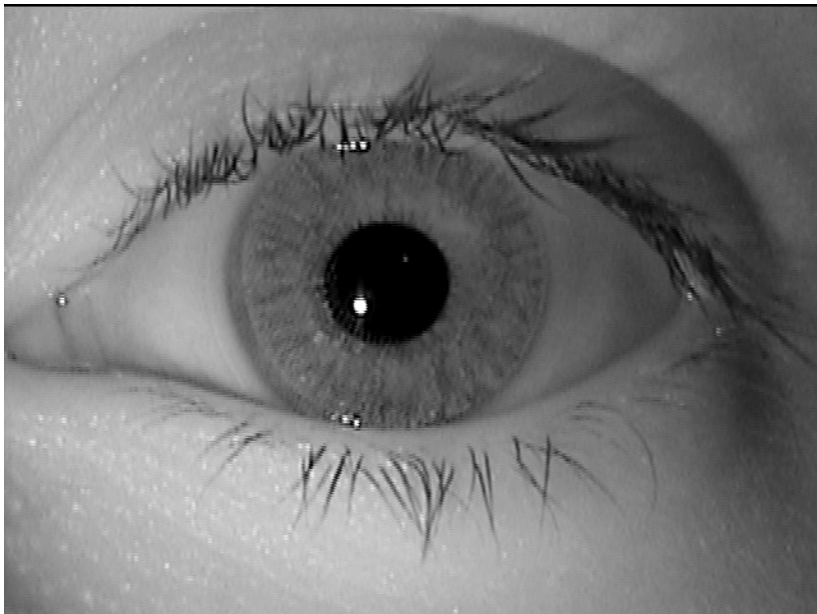
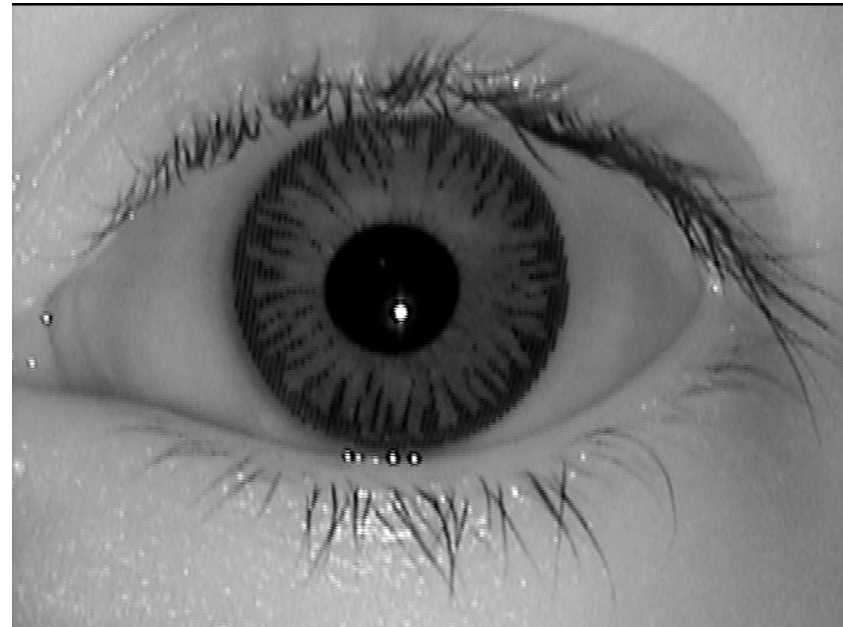
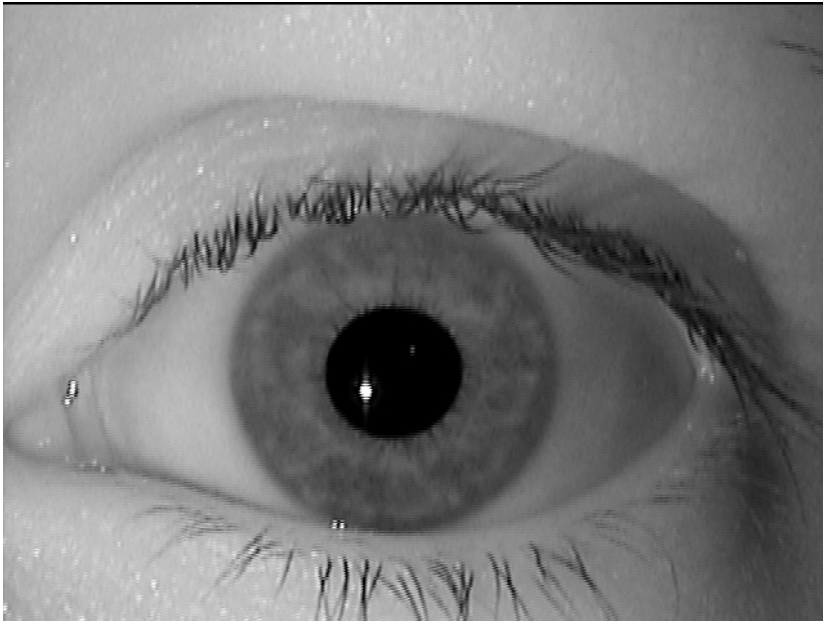


:)

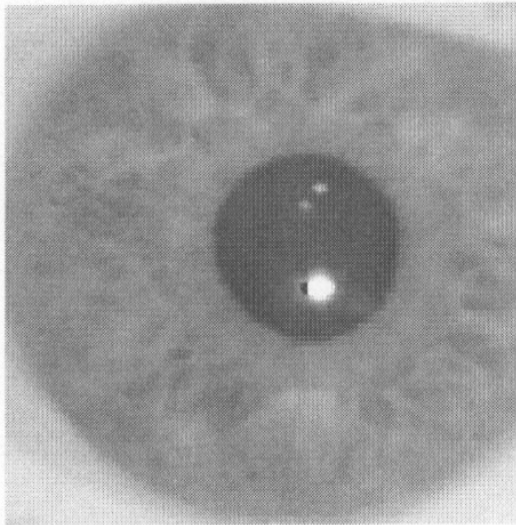


cosmetic contact lenses

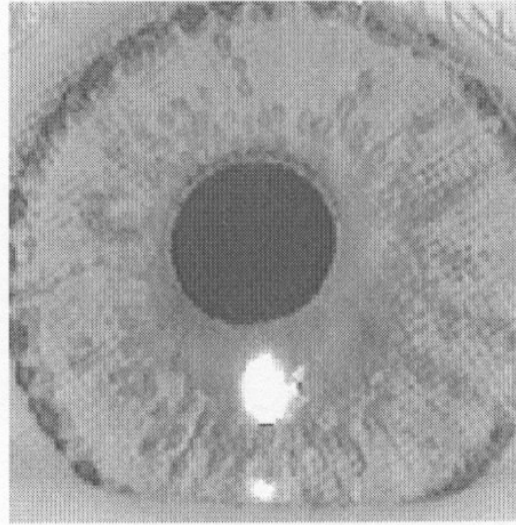
Contact lenses



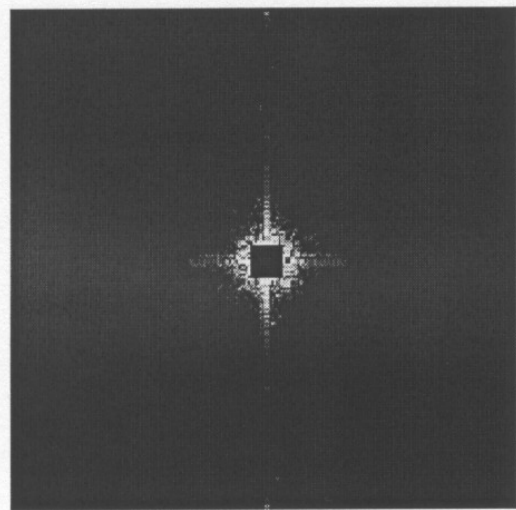
Fake iris attack solutions



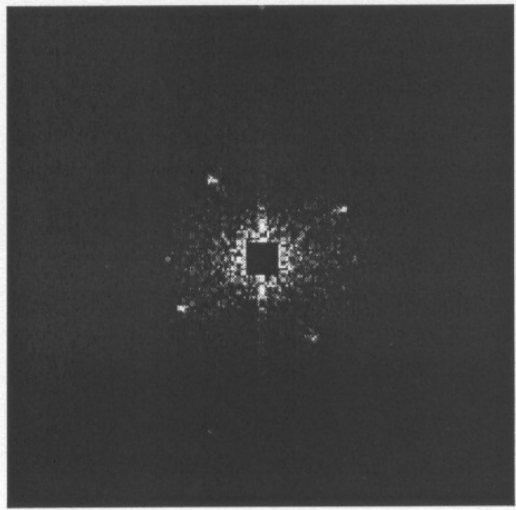
Natural Iris



Fake Iris printed on a contact lens



2D Fourier spectrum of natural Iris

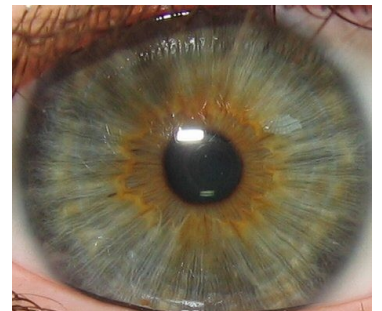


2D Fourier spectrum of fake Iris

- Checking for pupil-dilation effect (switching 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 screen
 - 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



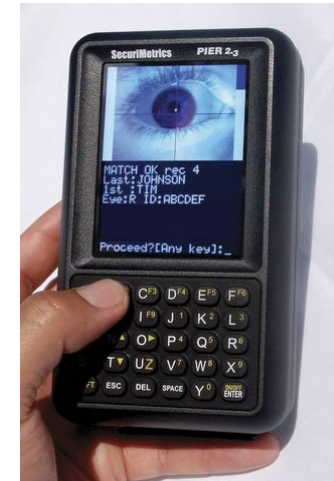
wall mounted
Entry access control
Panasonic ET300



IrisGuard IG - AD 100

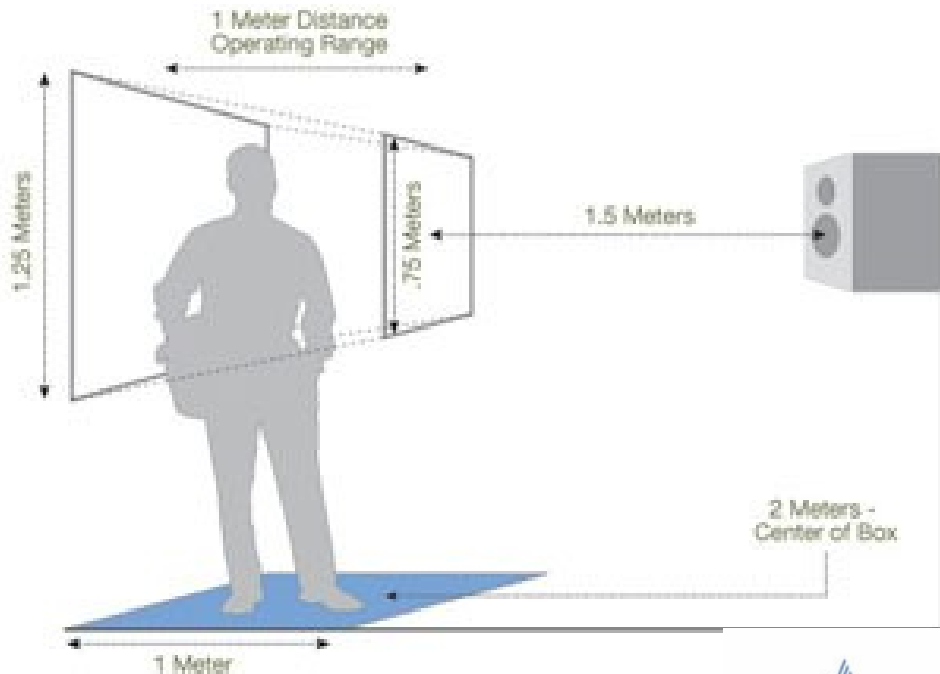


IrisGuard IG/H100



PIER 2.3, Hand-held,
SecuriMetricsInc.,

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 the imager, and open your eyes.

- Reduced need of subjects cooperation

Iris on the move



IOM PassPort **SRI International**
SARNOFF

- 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)

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 travellers)
- **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
 - [Watchlist of 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 60,000 persons caught since launch ALMualla 2005

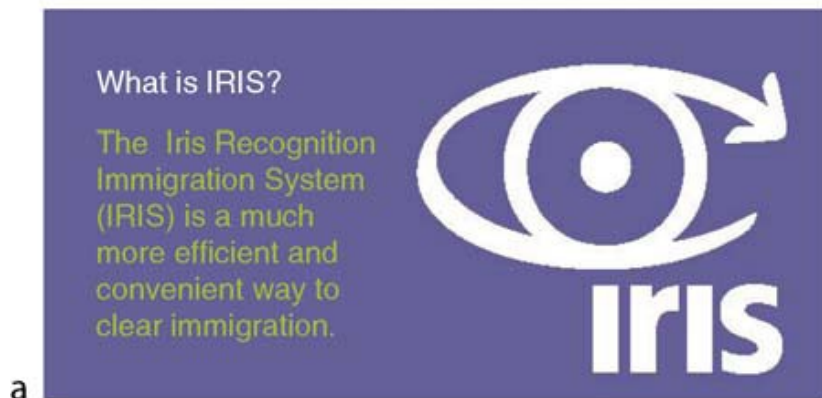


United Arab Emirates



Usage in the UK

- UK's *IRIS (Iris Recognition Immigration System)* replaces passport control
- Available at several airports in the UK
- Automatic counters for registered travellers
- Over 1 000 000 registered frequent flyers



The Netherlands

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



Access systems



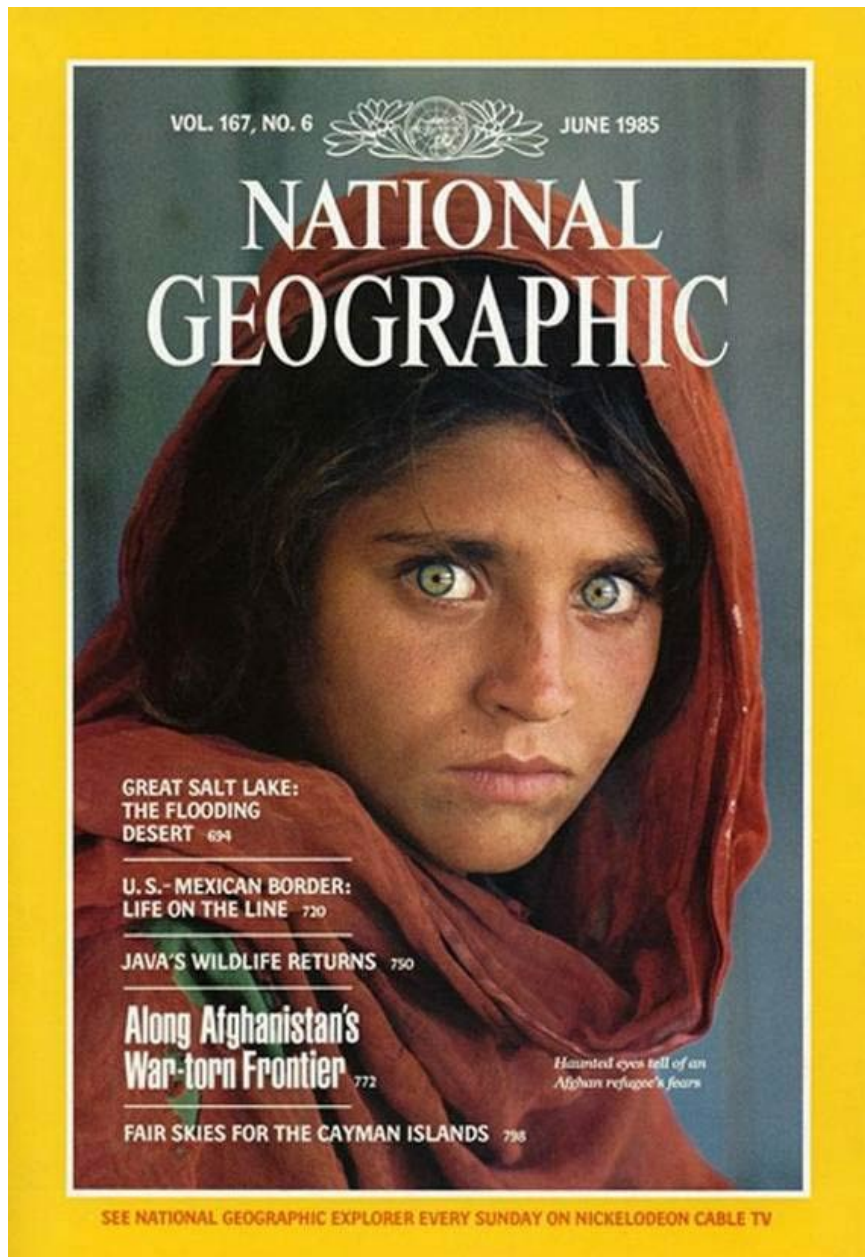
Residential Access to Condominium (and Lift Calling), Tokyo.

IRIS in humanitarian projects



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

Motivation: NG story



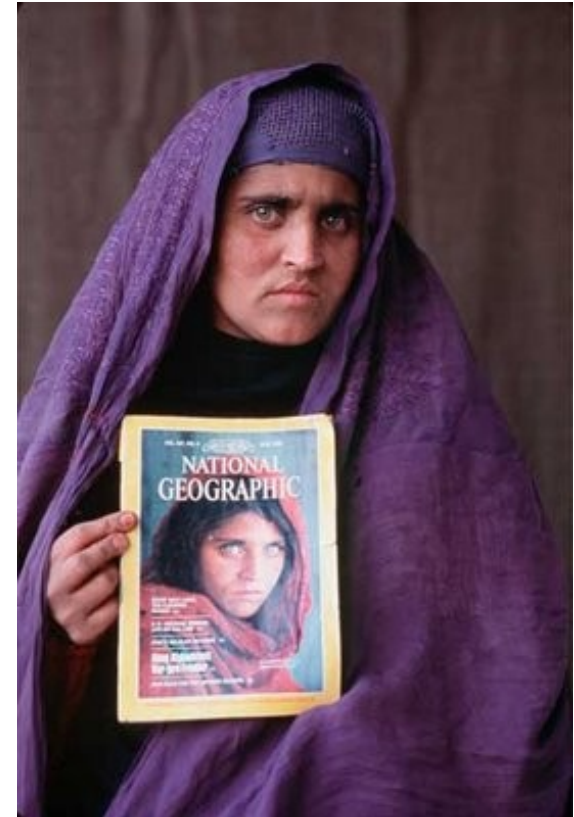
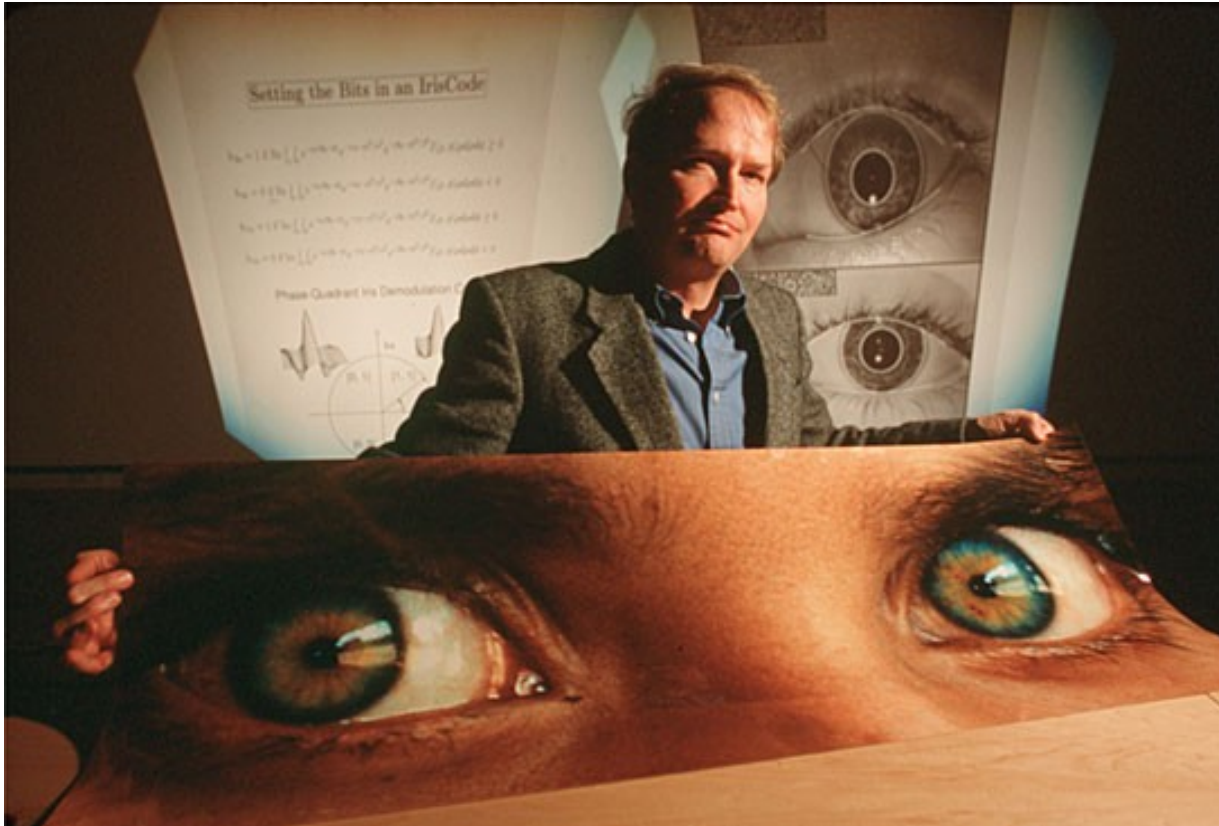
- National Geographic cover story: a girl refugee in Pakistanian refugee camp after her city in Afghanistan was bombed by USSR army.
- One of the most recognized pictures in the history of NG (“Afghan girl”)
- Photographed by S. McCurry in 1984

“Afghan girl” story continued

- McCurry tried to locate 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

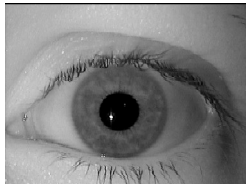


Core Technology Patent: "Biometric Personal Identification System Based on Iris Analysis", U.S. Patent No. 5 291 560 issued March 1, 1994 (J. Daugman)

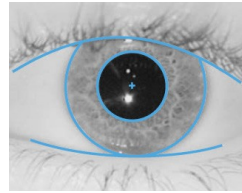
Summary

- Iris: stable and very individual property
- Not too obtrusive
- Highly suitable for biometric identification/verification
- Iris image rather difficult to capture (focusing, motion-blur, lighting, reflections, pupil dilation...)
- Capturing distances: ~cm to ~3m, time needed: ~1s
- Iris recognition systems already in operation in large-scale border and access control systems

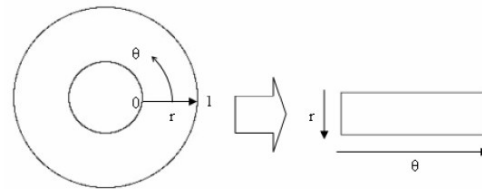
Iris recognition process



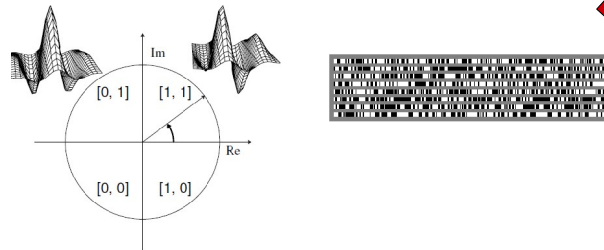
iris image



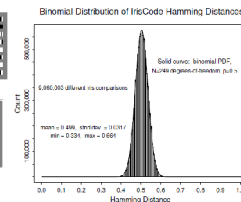
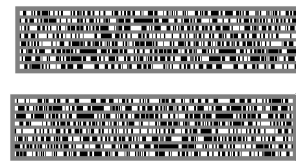
iris region segmentation



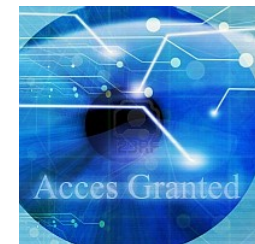
unwrapping



feature extraction & encoding



iris code comparison (database)



Result

Thank you for your attention

