# IRIS RECOGNITION AS A BIOMETRIC TECHNIQUE

**Abstract:**

**B**iometrics is a technology that automatically authenticates, identify, or verify an individual based on physiological or behavioral characteristics. This is accomplished by using computer technology in a non-invasive way to match patterns of live individuals in real time against enrolled records. The commonly used Biometric techniques include recognition of faces, hands, fingers, signatures, voices, fingerprints and irises for a person's identification and authentication. This paper discusses in detail the Iris Recognition as a Biometric Technique.

The iris being a protected internal organ whose random texture is stable throughout life can serve as a kind of living password that one need not remember but one always carries along. The rich details of iris patterns are captured by high resolution imaging systems. The iris recognition systems use executable software, which deploy algorithms for encoding and recognizing iris patterns. The recognition principle is the failure of a "Test of statistical independence "on iris phase structure encoded by multi-scale quadrature wavelets. The combinatorial complexity of this phase information across different persons spans about 244 degrees of freedom, whereas, the best fingerprint technology uses only about 60 to 70 degrees of freedom. This implies that the randomness of iris patterns has very high dimensionality and thus the recognition decisions are made with confidence levels high enough to support rapid and reliable exhaustive searches through national-sized databases.

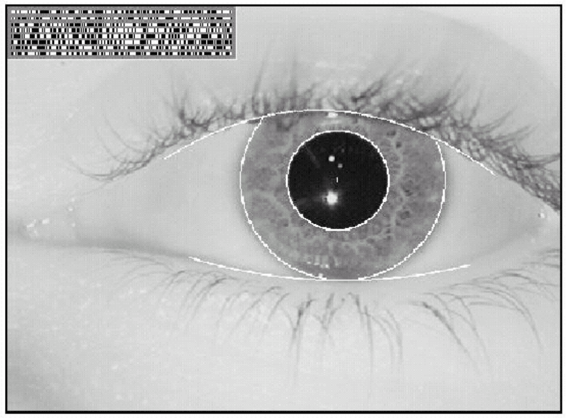
The purpose of this paper is to provide an overview of the processes involved in iris recognition including the localization of the iris in the image, the extraction of phase information and the test of statistical independence. This paper also discusses the applications of iris recognition in various fields and its advantages and disadvantages over other Biometric technologies. Finally, this paper outlines how the mysterious "Afghan girl," whose haunting, green-eyed gaze had long intrigued the world after she appeared on the cover of the *National Geographic* was traced after 18 years and identified by the Iris Recognition Technique.

**Key Words:** *Biometrics, imaging systems, iris recognition, algorithms, wavelets, fingerprint technology, recognition technique.*

**Conclusion:** Biometric is going to be the ultimate in recognizing the person through the physical characteristic of pattern. The pattern can be by identifying a person through finger print, or may be the face, or the pattern of any part of the body. Here is an attempt to recognize a person through IRIS , a part of the human eye.

## BIOMETRIC TECHNOLOGIES

Biometrics is defined as measurable physiological and or behavioral characteristics that can be utilized to verify the identity of an individual. The commonly used Biometric techniques include recognition of faces, hands, fingers, signatures, voices, fingerprints and irises for a person's identification and authentication. This paper discusses Iris Recognition as a Biometric Technique.



The iris is a protected internal organ of the eye, located behind the cornea and the aqueous humour, but in front of the lens. It is the only internal organ of the body that is normally visible externally. Images of the iris adequate for personal identification with very high confidence can be acquired from distances of up to about 3 feet (1 meter). The properties of the iris that enhance its suitability for use in high confidence identification systems include:

- Its inherent isolation and protection from the external environment;
- The impossibility of surgically modifying it without unacceptable risk to vision;
- Its physiological response to light, which provides one of several natural tests against artifice.

Iris recognition illustrates work in computer vision, pattern recognition, and the man-machine interface. Iris recognition achieves real-time, high confidence recognition of a person's identity by mathematical analysis of the random patterns that are visible within the iris of an eye from some distance. The iris being a protected internal organ whose random texture is stable throughout life can serve as a kind of **living password** that one need not remember but one always carries along. Because the randomness of iris patterns has very high dimensionality, recognition decisions are made with confidence levels high enough to support rapid and reliable exhaustive searches through national-sized databases. The Algorithms developed by John Daugman at Cambridge are the basis for all iris recognition systems worldwide.

To record an individual's iris code, a black-and-white video camera uses 30 frames per second to zoom in on the eye and "grab" a sharp image of the iris. A low-level incandescent light illuminates the iris so the video camera can focus on it, but the light is barely noticeable and used strictly to assist the camera. The camera can be set at a distance of four inches (10 centimeters) to 40 inches (one meter), depending on the scanning environment. When iris recognition is used for logging on to a personal computer or checking in at an airport, people need to be somewhat closer to the camera. An automatic cash machine, on the other hand, does not require such nearness.

One of the frames is then digitized and stored in a PC database of enrolled users. The whole procedure takes less than a few seconds, and can be fully computerized with voice prompts and auto focus. The iris record size is only 512 bytes with a resolution of 640 x 480, allowing for massive storage on a computer's hard drive.

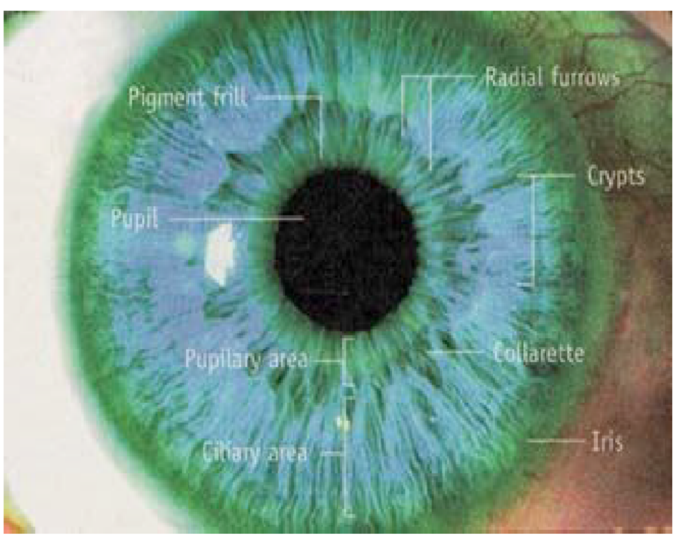
Scientists say that a person's retina can change with age, while an iris remains intact. And no two iris blueprints are mathematically alike, even between identical twins and triplets. Glasses and contact lenses, even colored ones, do not interfere with the process. In addition, recent medical advances such as refractive surgery; cataract surgery and cornea transplants do not change the iris' characteristics. In fact, it is impossible to modify the iris without risking blindness. And even a blind person can participate. As long as a sightless eye has an iris, that eye can be identified by iris recognition.

An iris has a mesh-like texture to it, with numerous overlays and patterns that can be measured by the computer. The iris-recognition software uses about 260 "degrees of freedom," or points of reference, to search the data for a match, whereas, the best fingerprint technology uses about 60 to 70 degrees of freedom.

## HOW IRIS RECOGNITION WORKS

Although small (11 mm) and sometimes problematic to image, the iris has the great mathematical advantage that its pattern variability among different persons is enormous. As a planar object its image is relatively insensitive to angle of illumination, and changes in viewing angle cause only affine transformations; even the nonaffine pattern distortion caused by pupillary dilation is readily reversible. Finally, the ease of localizing eyes in faces, and the distinctive annular shape of the iris, facilitate reliable and precise isolation of this feature and the creation of a size-invariant representation.

The iris begins to form in the third month of gestation and the structures creating its pattern are largely complete by the eighth month, although pigment accretion can continue into the first postnatal years. Its complex pattern can contain many distinctive features such as arching ligaments, furrows, ridges, crypts, rings, corona, freckles, and zigzag collarette, some of which are shown in the figure below:




Iris color is determined mainly by the density of melanin pigment.

The predominant texture of different irises seen with a visible light. Iris recognition leverages on the unique patterns of the human Iris for identification. A primary characteristic is the trabecular meshwork, a tissue that gives the appearance of dividing the iris in a radial fashion.

## FINDING AN IRIS IN AN IMAGE:

To capture the rich details of iris patterns, an imaging system should resolve a minimum of 70 pixels in iris radius. The iris and the pupil and the lower and upper eyelid boundaries are localized to single pixel precision. The result of all these localization operations is the isolation of iris tissue from other image regions.

## IRIS FEATURE ENCODING BY 2D WAVELET DEMODULATION:

An "**Iris Code**" is constructed by *demodulation* of the iris pattern. This process uses complex-valued 2D Gabor wavelets to extract the structure of the iris as a sequence of phasors (vectors in the complex plane), whose phase angles are quantized to set the bits in the Iris Code. This process is performed in a doubly dimensionless polar coordinate system that is invariant to the size of the iris (and hence invariant to the imaging distance and the optical magnification factor), and also invariant to the dilation diameter of the pupil within the iris. The demodulating wavelets are parameterized with four degrees-of-freedom: size, orientation, and two positional coordinates. The angle of each phasor is quantized to one of the four quadrants, setting two bits of phase information. This process is repeated all across the iris with many wavelet sizes, frequencies, and orientations, to extract 2,048 bits.. It amounts to a patch-wise phase quantization of the iris pattern Because the information extracted from the iris is inherently described in terms of phase, it is insensitive to contrast, camera gain, and illumination level (unlike correlation methods). The phase description is very compact, requiring only 256 bytes to represent each iris pattern. . Now an equal number of masking bits are also computed in algorithms to signify whether any iris region is obscured by eyelids, contains any eyelash occlusions, specular reflections, boundary artifacts of hard contact lenses, or poor signal-to-noise ratio and thus should be ignored in the demodulation code as artifact. Only phase information is used for recognizing irises because amplitude information is not very discriminating, and it depends upon extraneous factors such as imaging contrast, illumination, and camera gain.

## THE TEST OF STATISTICAL INDEPENDENCE: COMBINATORICS OF PHASE SEQUENCES

The key to iris recognition is the failure of a **test of statistical independence**, which involves so many degrees-of-freedom that this test is virtually guaranteed to be passed whenever the Iris Codes for two different eyes are compared, but to be uniquely failed when any eye's Iris Code is compared with another version of itself.

The test of statistical independence is implemented by the simple Boolean Exclusive-OR operator (XOR) applied to the 2,048 bit phase vectors that encode any two iris patterns, masked (AND'ed) by both of their corresponding mask bit vectors to prevent non-iris artifacts from influencing iris comparisons. The XOR operator detects disagreement between any corresponding pair of bits, while the AND operator ensures that the compared bits are both deemed to have been uncorrupted by eyelashes, eyelids, specular reflections, or other noise. The norms (|| ||) of the resultant XOR'ed phase bit vectors and of the AND'ed mask vectors are then measured in order to compute a fractional Hamming Distance as the measure of the dissimilarity between any two irises, whose two phase code bit vectors are denoted {*codeA, codeB*} and whose mask bit vectors are denoted {*maskA, maskB*}:

$$\text{Hamming Distance} = \frac{\|(codeA \otimes codeB) \cap maskA \cap maskB\|}{\|maskA \cap maskB\|}$$

The denominator tallies the total number of phase bits that mattered in iris comparisons after artifacts such as eyelashes and specular reflections were discounted, so the resulting Hamming Distance is a fractional measure of dissimilarity; **Hamming Distance = 0 would represent a perfect match**. The Boolean operators XOR and AND are applied in vector form to binary strings of length up to the word length of the CPU, as a single machine instruction. Thus for example on an ordinary 32-bit machine, any two integers between 0 and 4 billion can be XOR'ed in a single machine instruction to generate a third such integer, each of whose bits in a binary expansion is the XOR of the corresponding pair of bits of the original two integers. This implementation of the Hamming Distance computation in parallel 32-bit chunks enables extremely rapid comparisons of Iris Codes when searching through a large database to find a match. On a 300 MHz CPU, such exhaustive searches are performed at a rate of about 100,000 irises per second.

## RECOGNIZING IRISES REGARDLESS OF SIZE, POSITION, AND ORIENTATION

Robust representations for pattern recognition are invariant to changes in the size, position, and orientation of the patterns. In the case of iris recognition, this means the representation is invariant to the optical size of the iris in the image; the size of the pupil within the iris; the location of the iris within the image; and the iris orientation, which depends upon head tilt, torsional eye rotation within its socket, and camera angles.

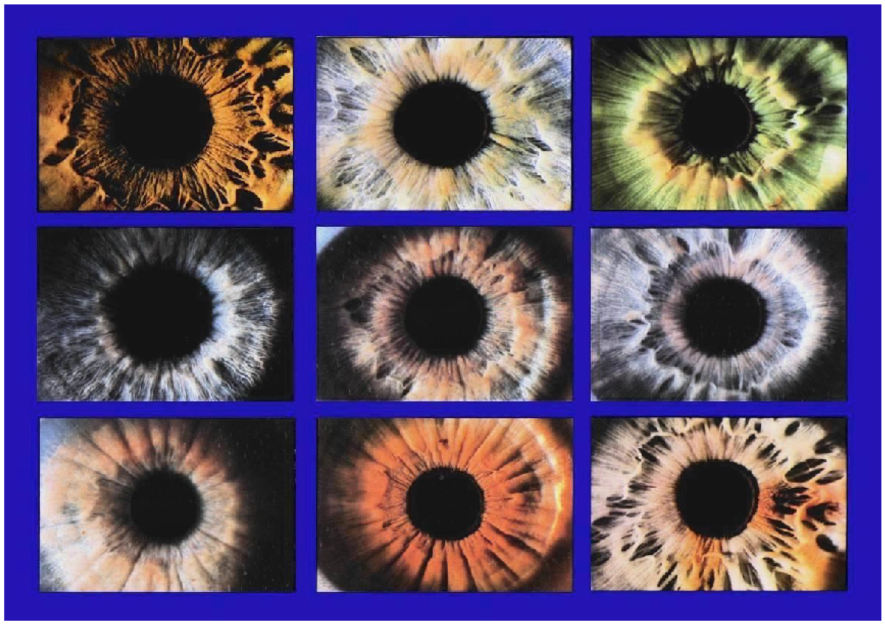
### Uniqueness of Failing the Test of Statistical Independence

Any two different irises are statistically "guaranteed" to pass this test of independence, and any two images that fail this test (i.e. produce HD ò 0.330) must be images of the same iris. **The Probability of two irises producing exactly the same code is 1 in 10 to the 78th power.** The uniqueness of the failure of the test of statistical independence is the basis for iris recognition.

## SOME CURRENT AND FUTURE APPLICATIONS OF IRIS RECOGNITION

- Computer login: the iris as a living password
- National border controls: the iris as a living passport
- Telephone call charging without cash, cards, or PIN numbers
- 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

Different kinds of Iris patterns:



## HOW THE AFGHAN GIRL WAS IDENTIFIED BY HER IRIS PATTERNS:

The photograph of an Afghan girl appeared on the cover of the June 1985 National Geographic. Her eyes had captivated the world since then. For 17 years the name of the young girl who stared so hauntingly was not known. Millions around the world wondered who that mysterious girl was

She was traced 18 years later to a remote part of Afghanistan to be Sharbat Gula where she was again photographed .She was identified by Iris recognition technique. First Iris Codes from both of her eyes as photographed in 1984 were computed. Then Iris Codes from both eye regions in the 2002 photograph were computed. With the search engine (i.e. the matching algorithm) on these Iris Codes, a Hamming Distance of 0.24 for her left eye, and 0.31 for her right eye was calculated. This means that the mathematical odds for different irises showing so little dissimilarity are 6 million to one for her right eye, and 10-to-the-15th-power to one for her left eye. The mysterious "Afghan girl," whose haunting, green-eyed gaze has long intrigued the world, was found.

## ADVANTAGES OF THE IRIS FOR IDENTIFICATION

- Highly protected, internal organ of the eye
- Externally visible; patterns imaged from a distance
- Iris patterns possess a high degree of randomness

- Variability: 244 degrees-of-freedom
- Entropy: 3.2 bits per square-millimeter
- Uniqueness: set by combinatorial complexity

- Changing pupil size confirms natural physiology
- Pre-natal morph genesis (7th month of gestation)
- Limited genetic penetrance of iris patterns
- Patterns apparently stable throughout life
- Encoding and decision-making are tractable
  - Image analysis and encoding time: 1 second
  - decidability index (d-prime): d' = 7.3 to 11.4
  - Search speed: 100,000 Iris Codes per second

## DISADVANTAGES OF THE IRIS FOR IDENTIFICATION

- Small target (1 cm) to acquire from a distance (1 m)
- Moving target ...within another... on yet another
- Located behind a curved, wet, reflecting surface
- Obscured by eyelashes, lenses, reflections
- Partially occluded by eyelids, often drooping
- Deforms non-elastically as pupil changes size
- Illumination should not be visible or bright

Inspite of these shortcomings, considering the reliability and high confidence levels achieved in recognition of a person's identity, Iris recognition finds enormous applications.

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