IRIS RECOGNITION

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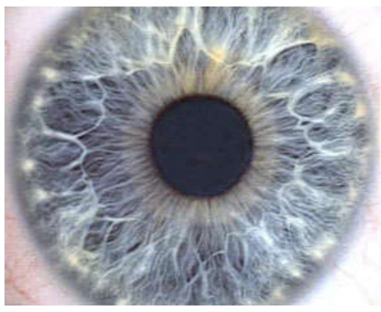


OVERVIEW

As with almost every new technology that seeks to find its place in everyday life, iris recognition has both the potential to be a convenience enhancer (including an access enhancer), but also the potential to be an obstacle or excluder if improperly configured or installed without consultation and guidance from disabled persons. Because it allows hands-free, automatic, rapid and reliable identification of persons, it can facilitate access for persons unable to engage in the standard mechanical transactions of access.

Humans have traditionally identified each other by their appearance, by the sound and content of their speech, and by context. If the other person is neither visible nor audible, e.g. when receiving their email, we either simply accept their asserted identity, allow it to establish itself by shared knowledge and context, or rely on special secret knowledge such as encryption keys. Identification amongst strangers in official interactions, such as immigration passport control or financial transactions, has traditionally relied upon special possessions (documents such as passports and identity cards), or secrets (e.g. passwords).

With the arrival of automation, identification of persons has continued to rely largely on special possessions (magnetic or optical stripe cards) and on secrets (computer login password, or cashpoint PIN number). These methods go back thousands of years: Bronze Age priests had special amulets to establish their identity, and the Roman centurions used secret military passwords. But the problem, of course, with identification based either on special possessions or on secret knowledge is that it only really establishes that the possession or the secret was present at the transaction. It does nothing to confirm that the holder of the special possession or of the secret was the rightful person.

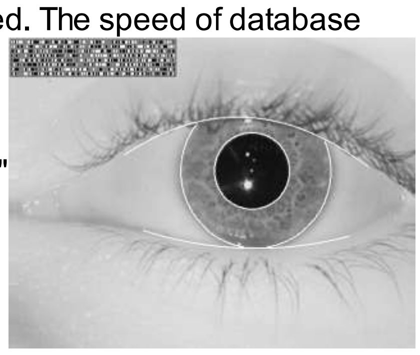
This fundamental problem with traditional methods of identification -- whether between human strangers, or identification of persons by machines -- took on new urgency on 11 September, 2001. Some of the terrorist hijackers who crashed the aeroplanes into buildings were on FBI "watch lists," but they were using false passports. With no reliable mechanism to confirm any connection between a passport (or other identity device) and its holder, 11 September was a catastrophe waiting to happen. The technologies called "biometrics" (from biological measurement) seek to tie identity much more tightly to a person's particular unique features. These could be anatomical, physiological, or even behavioural. The sound of a person's voice, or they way in which they sign their name, are examples of behavioural biometrics. Their blood type, or markers in their tissue or fluid samples (including DNA itself) are examples of physiological biometrics, although these would be used more typically in forensic applications rather than in real-time, live applications. Most currently used biometrics are anatomical: facial appearance, hand geometry, fingerprints, retinal vein patterns, and iris patterns.

This article aims to explore biometric issues of particular relevance to persons with disabilities. Will biometric identification mean more obstacles and exclusion? Or could biometrics actually be facilitators, and convenience enhancers? As the inventor of iris recognition, I am particularly concerned to ensure that the latter and not the former is the upshot of the use of the iris biometric. But these issues apply equally to all biometric identification systems. As developers of such systems, we need to solicit feedback and advice from persons with disabilities to ensure the maximum benefit for all from such technologies, and particularly to ensure that these technologies reduce rather than add to exclusion. I hope that the issues raised in this article will contribute to that goal.

First let me say a bit about iris recognition and how it works. The iris is an internal organ of the eye -- perhaps the only internal organ of the body that is routinely visible from outside -- and its patterns are resolvable with good videocameras from distances of up to about a meter. The iris is located behind the cornea of the eye, and behind the aqueous humour, but in front of the lens. Its only physiological purpose is of course to control the amount of light that enters the eye through the pupil, by the action of its dilator and sphynctor muscles that control pupil size, but its construction from elastic connective
tissue gives it a complex, fibrillous pattern. Its morphogenesis begins in the 3rd month of gestation and is largely complete by the 8th, although changes in pigmentation can occur during the first year of life (hence most babies are born with slate-blue eyes, regardless of their ultimate, genetically determined eye colour). There is no genetic determination of the detailed iris texture, as sighted readers can confirm just by examining the detailed texture in their left and right eyes (which are, of course, genetically identical). Apart from the occasional appearance of freckles or other pigmentation changes caused by some eyedrop treatments for glaucoma, there is no evidence for any change of iris pattern over a person's life. (There is a cult belief and practice called "iridology," which is like palm-reading: it claims to be able to read not only the health status of each organ in a person's body from particular points in the iris, to which each organ is somehow wired; but also to interpret personality, mood, and interpersonal compatibilities. Needless to say, iridology is hocus-pocus, and every published scientific study of its diagnostic claims has dismissed it as clinical fraud.)

As illustrated by the accompanying close-up iris photograph, iris patterns have a high degree of randomness in their structure. This is what makes them unique. Every biometric depends upon random variation amongst different persons in the chosen measurements, in order to guarantee that a particular pattern is unique to just one person and thus can serve as a reliable automatic identifier of them. The greater the degree of randomness, the greater the likelihood of uniqueness. This can be measured mathematically by the number of "degrees-of-freedom" in the template. This is essentially a count of the number of independent forms of variation, or the dimensions of variability, that are spanned by the biometric across different persons. For the case of iris patterns, there are about 250 degrees-of-freedom;
for fingerprints it is about 35, and for faces it is about 20. A good analogy (both for the connective tissue of the iris and also for this mathematical measure!) is throwing down a plate of sticky noodles. The sticky noodles will fall into a random pattern, whose complexity (and therefore whose uniqueness) depends on how many noodles there were in the plateful. An iris pattern is a bit like a plate of 250 sticky noodles, and so the combinatorics of possible patterns that the pectinate ligament in the trabecular meshwork of the iris can form is truly astronmical. More precisely, its combinatorics are binomial -- described by binomial distributions, as are the possible outcomes from tossing a coin 250 times in a row. The likelihood of getting all "heads" is 0.5 raised to the 250th power, which is roughly 10 raised to the minus 75th power.

My algorithms encode the iris pattern into an abstract mathematical description called an "IrisCode," which is the bar-code like bit stream shown in the top-left corner. This process relies upon two-dimensional wavelets (mathematical functions that are like restricted Fourier components, i.e. sinewaves multiplied by Gaussian envelopes to give them locality). The result of the wavelet analysis is that any piece of an iris can be said to have a certain phase. The extraction of phase information across the entire iris is called demodulation. The phase coordinates of every part of the iris are quantized to just two bit accuracy -- i.e. only the identity of a quadrant of the complex plane is encoded as the representation for each small piece of structure seen in the iris. This "phase sequence" allows an iris pattern to be encoded in a total of 512 bytes worth of information. Whenever a person presents his/her eye to a camera, its IrisCode is computed within a second or less, and then this is compared with all previously enrolled IrisCodes in the relevant database to see whether any of them match. An important point is that the person does not need to assert any identity; the algorithms are powerful enough (and fast enough) to {\it discover} their identity, if they have been seen before and enrolled. The speed of database search is about 100,000 IrisCodes per second. This ability to be recognized without having first to assert an identity -- e.g. by swiping a card, or by typing in a name or a PIN number -- is one potential advantage of iris identification for persons who have limited use of arms or hands. This "hands-free" use of iris recognition is possible because the probability of False Matches is so low that the algorithms can "afford" to search large databases exhaustively, rather than just answering a single yes/no question about a claimed identity. In many millions of IrisCode comparisons that have been done in tests by independent laboratories (e.g. the UK's NPL Labs), so far there has never been a single False Match reported.



The potential limitations of iris recognition for persons with various disabilities include the following:

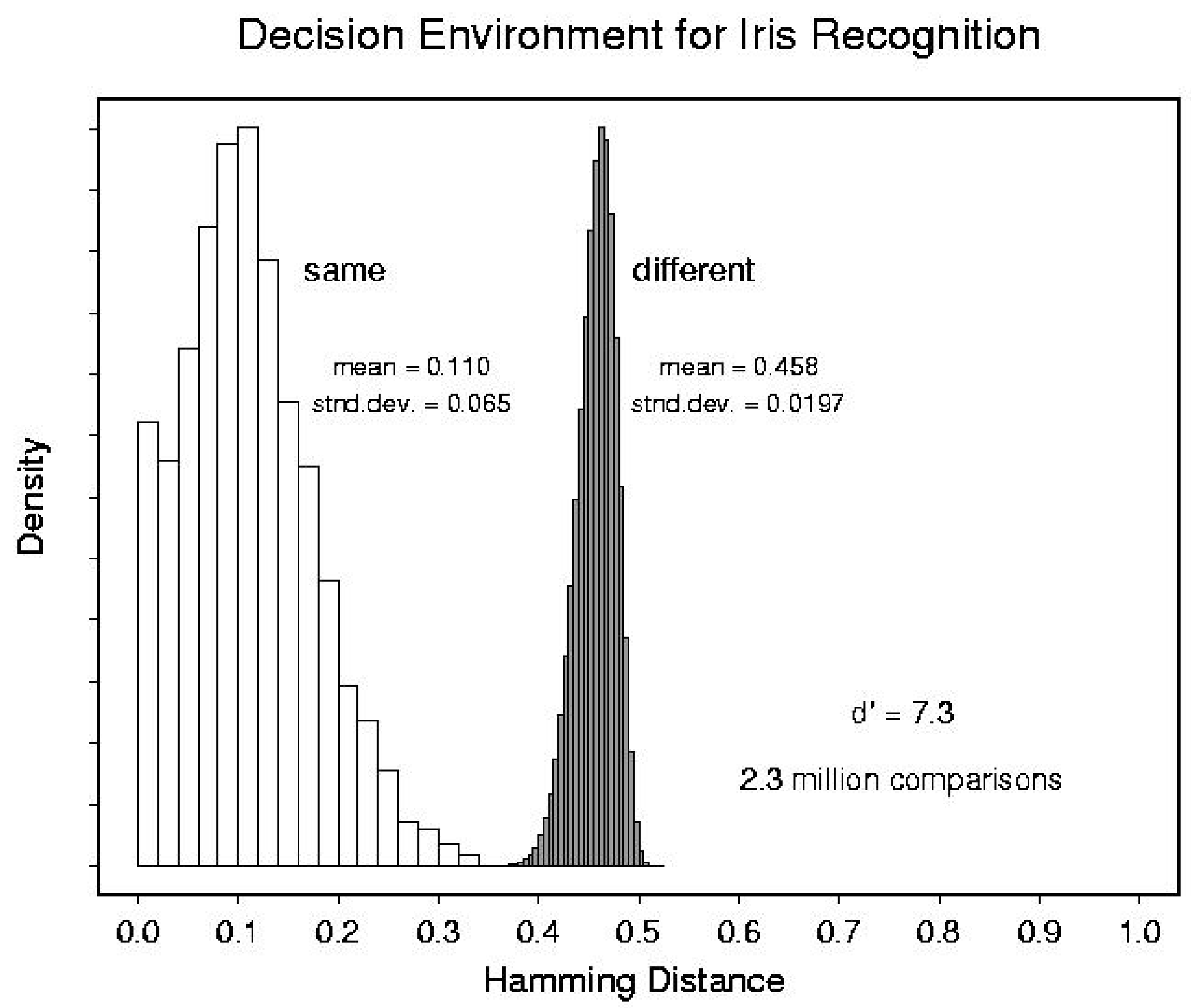
(1) A person must of course have an eye, with an iris. According to the US National Eye Institute (**http://www.nei.nih.gov**), the condition of aniridia (lack of an iris) occurs in 1.8 of 100,000 births. Because it is genetically linked, the condition usually affects both eyes according to the UK's Royal National Institute for the Blind (**http://www.rnib.org.uk/xpedio/groups/public/documents/publicwebsite/public_rnib003636.hcsp**), but its incidence covers a wide spectrum of partial conditions such as just chronically enlarged pupils. Iris recognition requires the pupil to have a diameter less than about 75% of the isis.

(2) Blind persons may have difficulty in getting themselves aligned with the iris camera at arm's length, because some such systems rely on visual feedback via a mirror or LCD display to guide the user into alignment with the camera. (Other more sophisticated iris cameras are mounted on automatic pan and tilt platforms that actively home in on an eye, including autozoom and autofocus, so very little cooperation from a user, or indeed vision, is needed.)

(3) Persons with pronounced nystagmus (tremor of the eyes) may have difficulty in presenting a stable image; however, some iris cameras now use stroboscopic (flashed infrared) illumination with very fast camera integration times, on the order of milliseconds, so tremor becomes unimportant for image capture.

Perhaps the most important disability issue involving iris recognition arises with wheelchair bound persons, because a wall-mounted iris camera presumes that a person's head is within a particular range of heights. All fixed cameras are swivel mounted to adjust for height, but still their "capture box" is limited to about 18" in height variation. Wheelchair access requires either that the entire unit can move up or down (e.g. on a sliding pole, as used in the EyeTicket (**http://www.eyeticket.com**) installations at airports such as Heathrow and Charlotte), or else that a tethered, handheld camera be used which a person picks up like a telephone handset and brings to the appropriate level of their eyes, within arm's length. Such handheld iris cameras are made by Panasonic (an example can be seen at (an example can be seen at **http://www.panasonic.com/medical_industrial/iris.asp**).

As with almost every new technology that seeks to find its place in everyday life, iris recognition has both the potential to be a convenience enhancer (including an access enhancer), but also the potential to be an obstacle or excluder if improperly configured or installed without consultation and guidance from disabled persons. Because it allows hands-free, automatic, rapid and reliable identification of persons, it can facilitate access for persons unable to engage in the standard mechanical transactions of access. But it must not presume universal uniformity among persons and their bodies. The variability of persons is, after all, the heart and soul of biometric technology.



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