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Comparative Study of IRIS Feature Extraction Algorithm

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Abstract:

This article reviewed the literature regarding iris recognition. Theprocess of iris recognition is discussed in the context of the mathematicalprinciples that underlie this procedure. Possible applications for irisrecognition are explored.

Keyword:

Irisrecognition, iris uniqueness, wavelets,statistical independence,Hamming distance,iris recognition applications.

1. Introduction:

Iris recognition is not a new idea but has only been available inpractical application for the last 10 to 15 years. This idea has beenfeatured in many science fiction movies but until recently was just atheoretical concept. Iris recognition is used for security purposes andis an almost foolproof entry-level access security means because of itsability to readily identify false irises (Henahan, 2002, ¶ 8). It has notbeen widely used because of the cost, but has applications that are everincreasing. Iris recognition will be a viable option for any security systemin the future.Iris recognition is a biometric that depends on the uniqueness of theiris. The iris is a unique organ that is composed of pigmented vessels andligaments forming unique linear marks, slight ridges, grooves, furrows, vasculature, and other similar features andmarks (Daugman, 2003a).Comparing more features of the iris increases the likelihood ofuniqueness. Since more features are being measured, it is less probablefor two irises to match. Another benefit of using the iris is its stability.The iris remains stable for a lifetime because it is not subjected to theenvironment, as it is protected by the cornea and aqueous humour.The process of iris recognition is complex. It begins by scanning aperson's iris (Henahan, 2002, ¶ 6). The individual stares into a camera forat least a second allowing the camera to scan their iris.

An algorithmprocesses thedigital image created by the camera to locate the iris. Oncethe iris has been located, another algorithm encodes the iris into a phasecode that is the 2048-bit binary representation of an iris (Daugman, 2003b).The phase code is then compared with a databaseof phase codeslooking for a match. On a 300 MHz Sun Microsystems processor morethan 100,000 iris codes can be compared in a second (Daugman, 2003a).In a matter of a few seconds an individual can have his/her eyes scannedand matched to an iris code in a database identifying the individual.

2. The Uniqueness of the Iris:

How can we be sure the iris is unique? In analysing the iris there mustbe bits of an iris phase code that are statistically independent.Statistically independent means an event's likelihood of occurrence isequally probable regardless ofthe outcome ofa given event (Larsen &Marx, 2001).The statistical independence of an iris can be determined byusing the Boolean Exclusive-Or, XOR, and AND operators on theiris phase bits of any two patterns (Daugman, 2003b). XOR is a bitcomparison operator that will return 0 when comparing like bitsand otherwise returns 1.ND is also a bit comparison operator thatwill return 1 only when comparing bits that are both 1. The XORoperation shows how the two iris patterns differ, and the AND operationeliminates the effects of background noise in the image. Thecombination of the XOR operator with the AND operator to normalizethe result produces a fractional Hamming distance.A fractional Hamming distance is used to quantify the differencebetween iris patterns. The Hamming distance of two vectors is thenumber of components in which the vectors differ in a particular vectorspace (Gallian, 2002). In this instance, the fractional Hamming distancewill always be between 0 and 1. For iris patterns, the Hamming distanceshould theoretically be 0.500 because a bit has an equally likely chanceof being 0 or 1 (Daugman, 2003b).Dr. John Daugman, a professor atCambridge University, analysed the Hamming distances by comparingover 4250 iris images.

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He found the distribution of Hamming distancesto be a perfect binomial distribution with a mean of 0.499 and a standarddeviation of 0.0317. A binomial distribution is a model based on a seriesof trials that have two possible outcomes (Larsen & Marx, 2001). Themean is the average of all measured values, while the standard deviationis amount that the values tend to vary from the mean. The observedmaximum value was 0.664, and the observed minimum value was 0.334.This means that it highly unlikely for two different irises to agree inmore than two thirds of their phase bits. By a simple calculation, thedegrees-of-freedom of the distribution is 249. This demonstrates that ofthe 2048 bits, only a small number are mutually independent due tocorresponding radial components that exist within an iris. These findingsdemonstrate the uniqueness of an iris using the Hamming distanceas a measurement.

Are the irises of two people with the same genetic makeup distinguishable?This is an important question because it would demonstrate apossible pitfall in this biometric. This condition hinders DNA testingbecause identical twins, twins from the same embryo, yield the sameresults in a DNA test. Any given person has a genetically identical pairof left and right irises that can be compared (Daugman & Downing, 2001). In a similar analysis done by Daugman, 648 iris images from 324people were subjected to the same deviation for this analysis were 0.497 and 0.031, respectively. This study was repeated with theirises from identical twins and yielded a similar result. These studies showthat an individual has two unique irises, and a pair of twins has four unique irises. Thus, an iris image is independent of an identical geneticmakeup.

3. Locating the Iris:

The iris is captured in an image by a camera. The camera needs to beable to photograph a picture in the 700 to 900 nanometres range so thatit will not be detected by the person's iris during imaging (Daugman,2003b). The camera may or may not have a wide-angle lens yielding ahigher resolution, but in either case a mirror is used to utilize feedbackfor the image. These conditions must be met in order for the iris imageto have the necessary 50-pixel minimum size of the iris radius.Once the image of the iris is obtained, the iris needs to be locatedwithin the image.There are three variables within the image that are neededto fully locate the iris: the centre coordinates, the iris radius, and the pupilradius (Daugman, 2003b). An algorithm determines the maximum contour integral derivatives using the three variables to define a path of contour integrationfor each of the variables. The complex analysis of the algorithm findsthe contour paths defining the outer and inner circumferences of the iris.Statistical estimation changes the circular paths of the integral derivatives toarc-shaped paths that best fit both iris boundaries.

4. Encoding the Iris Image:

Once the iris has been located, it must be encoded into an iris phase code. The iris image is encoded using two-dimensional Gabor wavelets (Daugman,2003a).A wavelet is a correspondence to a signal in waveform of a finite length (Wavelet, 2005, ¶ 2). A wavelet transform may be used to compile raw data,like an image,and encode it into a compressed file.This application can be useddirectly in iris recognition for the encoding process. Daugman uses wavelets tocreate more than two thousand phase bits from a raw image in a dimensionlesspolar coordinate system(2004).The system is dimensionless to allow formore flexibility when comparing iris images of different size and quality.Polarcoordinates are used because they represent these curves in a simpler waycompared to other coordinate systems. Each bit is determined by its phase coordinates to minimizethe impacts of errors. Masking bits are also used tominimize the effects of eyelids, eyelashes, contacts, and other hindrances. Theuse of phase coordinates makes the encoding resilient to out-of-focus imagesbecause it prevents all out-of-focus irises from looking similar, as is the casewith facial recognition.Once the iris has been encoded, it can then be compared to any other irisencoding. With comparison algorithms, an iris mapping can be compared tomore than 100,000 different irises within a second on a 300 MHz Sunworkstation (Daugman, 2004). As computer speeds increase, the number ofcomparisons will only increase and make the process faster. The processis completed and a match is found in only a matter of seconds, making it veryefficient.

5. Matching Iris Codes:

The question remains, what constitutes a match? Specifically, thenumber of iris phase bits that need to correspond for a match must bedetermined (Daugman, 2004).

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The number of phase bits required for a matchis decided based on the specific application regarding how many irises need tobe compared. Irises need to be matched regardless of their size, position, orientation. This is accomplished by placing the image into a dimensionlesspolar coordinate system. Since the inner to outer boundary range of the irisis defined to be the unit interval, the pupil dilation and location becomesinvariant.The criteria used to decide if iris codes match is called the Hammingdistance criterion, which is the integration of the density function raised to thepower of the number of independent tests.A density function is the sum of allprobabilities of a possible outcome given a random variable, which in this caseis the Hamming distance of an iris phase code. A smaller criterion results in anexponentially decreasing chance of having a false match. This allowsthe strictness of matching irises to easily change for the particular application. A Hamming distance criterion of 0.26 gives the odds of a falsematch of 1 in 10 trillion, while a criterion of 0.32 gives the odds of 1 in 26million.The numeric values of 0.26 and 0.32 represent the fractional amountthat two iris codes can differ while still being considered a match in theirrespective instances.

6. Algorithms for IRIS Recognition:

Boles and Boashash (1998) decomposes one-dimensional intensitysignals computed on circles in the iris image to characterize the texture of theiris and use zero-crossings of the decomposed signals for the featurerepresentation. Iris matching is based on two dissimilarity functions. Thenumber of zero-crossings can differ among iris image samples of an identicaliris due to noises. This method is improved (Sanchez Avila and SanchezReilla 2005) in which it is assumed that if two samples are acquired from anidentical iris, the distance between corresponding pairs of zero-crossing inone sample and the other is less than given threshold value. However, thespurious zero-crossing points can degrade the performance.Kong and Zhang (2001) propose an eyelash and reflectionsegmentation in their algorithm. The overall system is developed based on thealgorithm of Boles and Boashash (1998) with the addition of an eyelash andreflection segmentation model. The strong reflections are detected by setting athreshold for the intensity value, and the weak reflections are detected byusing a statistical model on the intensity distribution. They tried four types of1-D wavelets (Mexican hat, Haar wavelet, Shannon, and Gabor) to extract theiris features.

In matching, the dissimilarity between a pair of iris codes isdefined by L1 norm. Chen et al (2002) proposes the use of an "S-irisencoding" which is generated from the inner product of the output from a 1DLog Gabor filter and secret pseudorandom numbers. In the segmentationstage, first an edge map is generated using a Canny edge detector. A circularHough transform is used to obtain the iris boundaries. Linear Houghtransform is used in excluding the eyelid and eyelash noises. Then the isolatediris part is unwrapped into a rectangle using Daugman's rubber sheet model(Daugman 2004). Then the final iris code is generated from the inner productof the output from a 1D Log Gabor filter and secret pseudo random numbers.In matching, Hamming distance is used to indicate the dissimilarity between apair of iris codes.

7. Applications for Iris Recognition:

Iris recognition has tremendous potential for security in any field.The iris is extremely unique and cannot be artificially impersonated by a photograph(Daugman, 2003).This enables security to be able to restrict access to specificindividuals. An iris is an internal organ making it immune to environmentaleffects. Since an iris does not change over the course of a lifetime, once an irisis encoded it does not need to be updated. The only drawback to iris recognitionas a security instalment is its price, which will only decrease as it becomesmore widely used.A recent application of iris recognition has been in the transportationindustry, most notably airline travel. The security advantages given by irisrecognition software have a strong potential to fix problems in transportation(Breault, 2005). Its most widely publicized use is in airport security. IBM andthe Schiphol Group engaged in a joint venture to create a product that uses irisrecognition to allow passengers to bypass airport security (IBM,2002,¶ 5).Thisproduct is already being used in Amsterdam. A similar product has beeninstalled in London's Heathrow, New York's JFK, and Washington's Dullesairports (Airport, 2002, ¶ 2 & 3). These machines expedite the process ofpassengers going through airport security, allowing the airports to run moreefficiently. Iris recognition is also used for immigration clearance, airline crewsecurity clearance, airport employee access to restricted areas, and as means ofscreening arriving passengers for a list of expelled persons from a nation(Daugman, 2005). This technology is in place in the United States, Great-Britain, Germany, Canada, Japan, Italy, and the United Arab Emirates.

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8. Conclusion:

Iris recognition has proven to be a very useful and versatile security measure.It is a quick and accurate way of identifying an individualwith no room for human error. Iris recognition is widely used in the transportationindustry and can have many applications in other fields where security isnecessary. Its use has been successful with little to no exception, and irisrecognitionwill prove to be a widely used security measure in the future.

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