# Development of an Iris-Based Access Control System Using a Two-Level Segmentation Approach.

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**ABSTRACT**

*Security of lives and assets has become a very interesting issue worldwide. Ability to restrict access to unauthorized users via an identification system that cannot be compromised at a very fast rate is highly desirable because it can be very costly if not achievable. In this work, a new segmentation technique that is suitable for segmenting black people's irises was developed. The system was simulated using irises of black people's faces captured in Nigeria and iris images from Chinese Academy of Sciences Institute of Automation (CASIA [1]), a standard iris database. The False Acceptance Rate(FAR) and False Rejection Rate(FRR) of the two image databases were obtained with varying Hamming Distances of 0.26, 0.30, 0.35, 0.39 and 0.45 respectively.*

Keywords- Biometrics, Iris Recognition, Segmentation, Authentication, Morphological.

## 1 INTRODUCTION

Adequate security of life and assets is one of the most paramount issues in the society today. Hence, the need to control user's access to places, homes, events, organizations etc. The most critical part of access control is authentication, which can be described as the process of verifying the identity of an individual or entity. Traditional personal identification schemes employ (1) something that an individual has (e.g. smart cards, ID cards etc.) or (2) some secret knowledge that the individual possesses (e.g. passwords, personal identification numbers (PINS), etc). These schemes can be unreliable and problematic. Passwords may be forgotten or intentionally compromised; smart cards may be lost, forged or stolen [2] and even the security personnel might be easily influenced to compromise. In essence, these two earlier schemes do not provide a robust and secure authentication as the first has been overtaken by impersonation and the latter, by hacking. In recent times, schemes based on who the individual is i.e. some physiological or behavioural characteristics like the iris, fingerprint, retina scan, voice e.t.c. are employed in identification and authentication. Iris recognition system is one of the most reliable leading technology that combines computer vision, pattern recognition, statistical inference, and optics. [3] Also, It is not subject to deleterious effect of aging. [4] The uniqueness of the iris is such that its details are phenotypically unique, that is, no two are exactly alike, not even among twins or even between a person's two eyes [5]. Again, iris pattern is stable throughout life [6] except in the case of cataract surgery, accidents or other eye-related problems.

### 1.2 AREAS OF APPLICATION

These include ATM operations, Police affairs, Electronic- Government affairs, Network security, Impersonation, Immigration systems, Airports, Border control, safety and reliability of electronic commerce, Confirmation of student identity for distant learning and examinations to mention but a few.

### 2.1 THE HUMAN IRIS

The iris is a thin circular diaphragm, lying between the cornea and the lens of the human eye [7]. At its centre is the pupil, through which light rays enter the eye. Its outer boundary is surrounded by the sclera or the white part of the eye. The function of the iris is to control the amount of light entering the pupil.


**Figure 1 A schematic of the human eye.**

### 2.2 IRIS RECOGNITION SUB-SYSTEMS

Five stages involved in an iris recognition system are:

- Iris image Acquisition: Capturing the eye image from a digital iris camera.
- Image Segmentation: Isolating the actual Iris region in digital eye image.

  An image is considered segmented only if all of the following three conditions are satisfied:

  (1) Localization of the Inner boundary of the iris. (2) Localization of the Outer boundary of the iris. (3) Upper and lower eyelid detection of the area covering the iris region [8].
- Feature Extraction: Extracting the most discriminating information present in an Iris pattern.
- Feature Encoding: Decomposition of the Iris Image to create a Biometric template.
- Matching: Establishing a similarity or otherwise between two Iris templates .

### 2.3 REVIEW OF RELATED WORK

The history of iris recognition goes back to mid 19th-century when the French physician, Alphonse Bertillon, studied the use of eye colour as an identifier. [9] . However, it is believed that the main idea of using iris patterns for identification, the way we know it today, was first introduced by an eye surgeon, Frank Burch, in 1936. [10]. In 1987, two ophthalmologists', Flom and San Francisco, patented this idea . Daugman, a professor at Harvard University studied the possibility of developing an iris recognition algorithm based on the recommendation proposed by Bertillon. Currently, Daugman's iris recognition system is installed in several airports worldwide. A few years after the publication of the first algorithm by Daugman, other researchers developed new iris recognition algorithms. Systems presented by [11]; [12]; [13]; [14]; [15] are some of the well-known algorithms so far.

By now, main methods of iris recognition include: regarding the iris image as the modulation result based on multi-scale Gabor wavelets, Daugman encoded the phase information as iris features and this is based on a test of statistical independence. After was area-based image registration used by

[16] . Wildes employed the normalized and got a lot of attention for the last few decades in biometric technology. Correlation results at four different resolutions as the matching metric was done by [11]. The wavelet transform is used by Boles for iris recognition as in [12] . [11] and [12] only used some small image sets for performance evaluation, while Daugman has used 4258 images from over 200 people in 2004..

It is very interesting to note however that for all the works done by the afore-mentioned researchers, their test databases were populated from Chinese Academy of Sciences' Institute of Automation (CASIA), CSBR(2005) iris images, UPOL [17]; UBIRIS [18] etc , only involving white eyes (Chinese, European eyes) particularly taken under favourable, standard conditions.

## 3.1 DESIGN CONSIDERATION AND BACKGROUND THEORY

Iris recognition systems are among the most accurate personal biometric identification systems. However, the acquisition of a workable iris images requires strict co-operation of the user; otherwise, the image will be rejected by a verification module because of its poor quality, thus inducing a high False Reject Rate (FRR). In 2010, [19] . affirmed that the FRR may also increase when iris localization fails or when the pupil is too dilated, leading to inaccurate localization and extraction. So, constant improvement is being witnessed in localization i.e, segmentation algorithms.

Of the five basic stages involved in an iris recognition system, segmentation phase, being one of the two most important is looked into.

### 3.2 DATA NEED

CASIA: among the public and freely available iris image databases for biometric purposes is the CASIA iris database, the most widely used for iris biometric purposes (captured under good positioning and illumination condition).Here we used CASIA Version 1 of 108 subjects, 7 images per person.

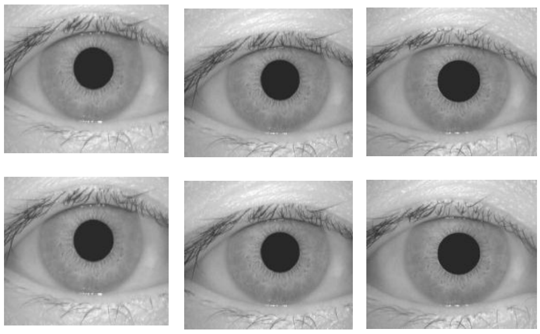


Figure 2a CASIA iris images.(Source: http://www.sinobiometrics.com., 2009)

BLACK FACES IRIS: Iris images captured within Nigeria people was also used to test the performance of the recognition system. A total of 150 images was collected for experimentation from 15 subjects with 10 samples each.

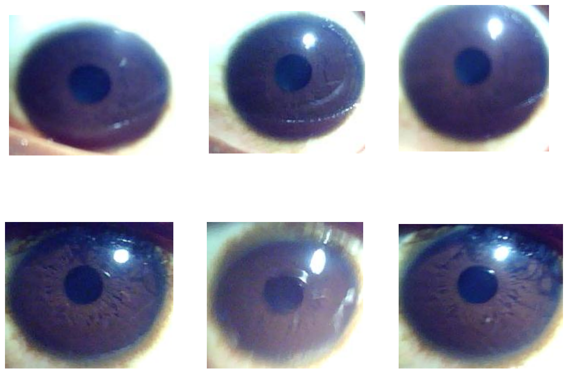


Figure 2b Black iris images.

### 3.3 SEGMENTATION

**HOUGH TRANSFORM ON CASIA IRIS DATABASE**

A first attempt at segmentation was done using Hough Transform since it performs better than other localization techniques in case of occlusion due to eyelids and eyelashes**.** It is an automatic segmentation algorithm employed to deduce the radius and center coordinates of the pupil and iris region. It's parameters are the centre coordinates $x_c$ and $y_c$, and the radius r, which are able to define any circle according to the equation

$$x_c^2 + y_c^2 - r^2 = 0 \qquad (1)$$

It also detect eyelids, approximating the upper and lower eyelids with parabolic arcs, which are represented as

$$\left(-(x-h_j)\sin\theta_j + (y-k_j)\cos\theta_j\right)^2 = a_j\left((x-h_j)\cos\theta_j + (y-k_j)\sin\theta_j\right) \qquad (2)$$

Where $a_j$ controls the curvature, ($h_j$, $k_j$) is the peak of the parabola and Ø is the angle of rotation relative to the x-axis.

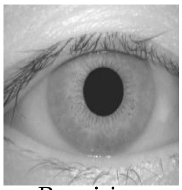
And because inner and outer iris boundaries are not concentric like the pupil, integrodifferential operator is performed around the pupil center and the iris radius in order to find the iris center according to equation 3.

$$max_{(r,x_0,y_0)} \left| G_\sigma(r) * \partial \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right| \qquad (3)$$

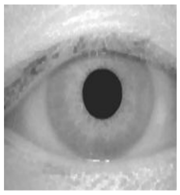
Where I(x, y) is the eye image, r is the radius to search for, Gσ (r) is a Gaussian smoothing function, and s is the contour of the circle given by r, $x_0$, $y_0$. The operator searches for the circular path where there is maximum change in pixel values, by varying the radius and centre x and y position of the circular contour.

The segmentation results obtained is as shown in Figures 3 and 4. With Hough Transform, a complete segmentation of the CASIA eyes was obtained as shown in figures 3a-h. But on using the same segmentation scheme on the raw black iris images, segmentation could not be achieved.(Figure 4a-h).This is due to poor contrast at the pupil-iris and iris-sclera boundary and illumination noise(Fig. 2b).

Therefore, to facilitate the segmentation of the black irises that was difficult to segment, a combination of the **Hough Transform** and Daugman's **Integro-differential Operator** was done on the raw iris images after some **morphological operations** .


(a) Raw iris

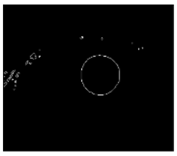

(b) Morphological opening



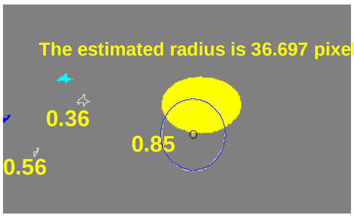
(c **)** Morphological closing **(d)** Binary compliment of the morphological images


(e) Morphological opening Binary image


(f) Morphological closing Binary image

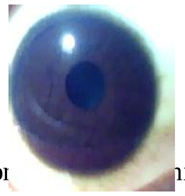


(g) Edges in the image




(h) Final Binary image

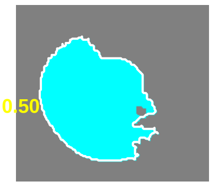
Figure 3a-h Hough Transform of an iris in CASIA iris database



( (b)Mo ing

(c)Morphological closing (d) Binary compliment of the morphological images

(e) Morphological opening Binary image




(h) Morphological closing Binary image

Figure 4. Hough Transform of an iris in black iris database.

With Hough Transform, a complete segmentation of the CASIA eyes was obtained as shown in figures 3a-h. But on using the same segmentation scheme on the raw black iris images, segmentation could not be achieved. This is because the (pupil-iris) and the (iris-sclera) boundary could not be accurately located due to poorly distinguishable colour contrasts in the different eye region. Therefore, modifying the values in the intensity image provided adjustment to the contrast which is useful for pupil detection being a very dark area with relatively constant values.

Hough transform uses an edge calculation technique to approximate the position of the eye in the global image (center of the pupil), and integro-differential operator to more precisely detect the pupil boundary, the iris center and the iris boundary.

**Morphological operations on the eye image**

In order to take advantage of the characteristics of the pupil described above, the image was refined in several steps using morphological operations provided by Matlab in order to obtain a reliable binary image of the pupil. Such operation includes:

- Image Fill
- Image Resize
- Image Compliment
- Histogram Equalization

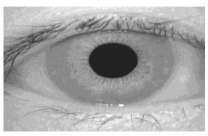
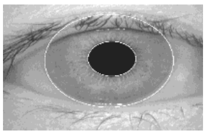


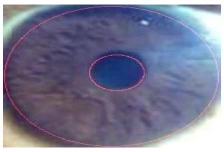
Figure 5 **(a)** raw

CASIA eye image



(b) CASIA eye image after segmentation.

Figure 6 (a) raw black eye image



(b) Black eye image after segmentation

**3.4 Feature Extraction**

A feature extraction based on Enhanced Inverse Analytical Fourier-Mellin Transforms was used to extract the isolated iris texture. [20] .

**3.5 Feature Matching**

The Hamming distance gives a measure of how many bits are the same between two bit patterns [16]. Using the Hamming distance of two bit patterns, a decision can be made as to whether the two patterns were generated from different irises or from the same one.

In comparing the bit patterns X and Y, the Hamming distance, HD, is defined as the sum of disagreeing bits (sum of the exclusive-OR between X and Y) over N, the total number of bits in the bit pattern.

**4.1 RESULTS**

System Specification - 2.20GHz processor with 3.0 GByte RAM.

Performance evaluation is based on:

- Receiver Operating Curve (False Accept Rate (FAR) and False Reject Rate (FRR) ).
- Recognition Accuracy.

The simulated results of the entire system are as illustrated in the tables 1 and 2 and the corresponding graphs of figures 8 to 12.

Table 1 CASIA Iris Recognition Accuracy

| Hamming Distance | FAR(%) | FRR(%) |
|---|---|---|
| 0.26 | 0.00 | 26.13 |
| 0.30 | 0.00 | 15.43 |
| 0.35 | 0.00 | 6.69 |
| 0.39 | 0.00 | 2.78 |
| 0.45 | 26.10 | 0.82 |

Table 2 Black Iris Recognition Accuracy

| Hamming Distance | FAR(%) | FRR(%) |
|---|---|---|
| 0.26 | 0.00 | 88.00 |
| 0.30 | 0.03 | 46.67 |
| 0.35 | 0.17 | 26.67 |
| 0.39 | 0.33 | 20.00 |
| 0.45 | 0.57 | 3.33 |

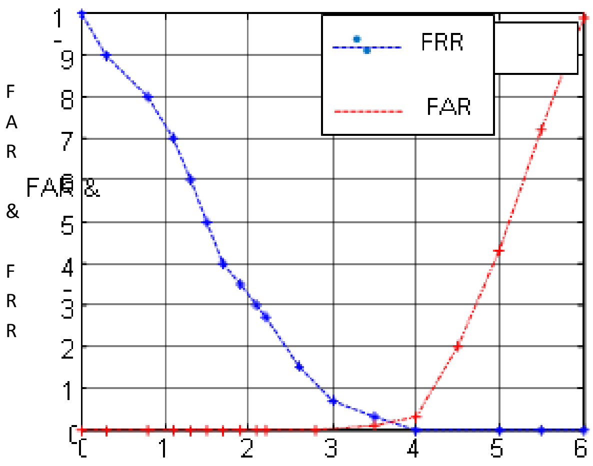



Figure 8 FAR and FRR for iris recognition using CASIA database.

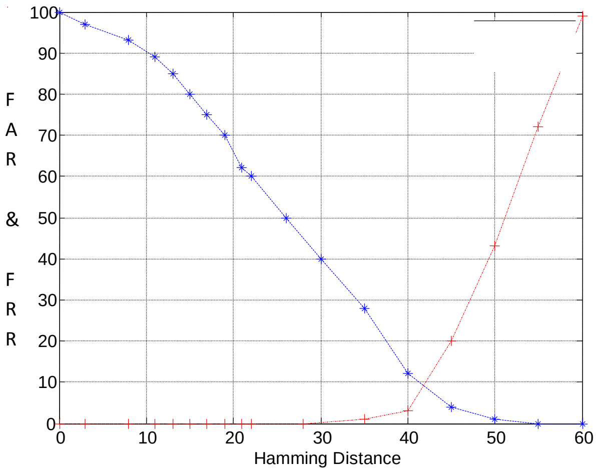



Figure 9 FAR and FRR for iris recognition using black iris database.

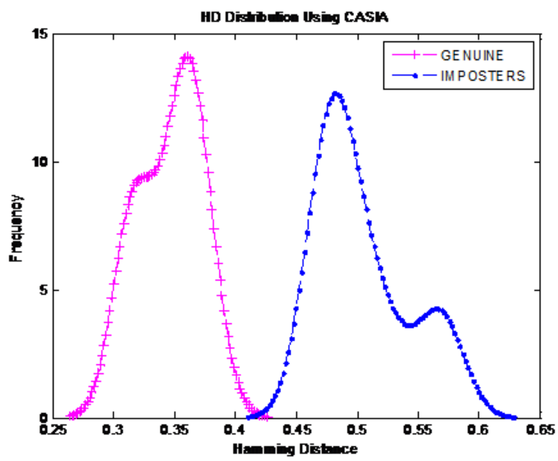



Figure 10 Genuine versus Imposters distribution for recognition with CASIA iris

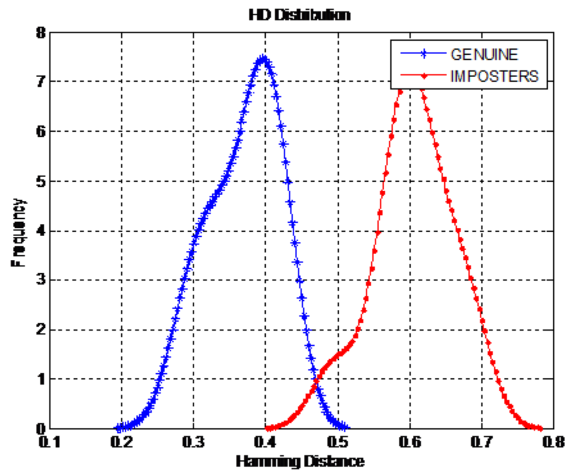



Figure 11 Genuine versus Imposters distribution for recognition with black iris

### 4.2 DISCUSSION

The system was simulated with CASIA Iris images and the black faces images. Iris location using Hough transform perfectly segments the CASIA Irises but the blacks were segmented with a combination of Hough transform and integro-differential operator with morphological reconstruction.

Table 1 showed the degree of recognition of CASIA iris images at varying Hamming distance(HD) of 0.26,0.30,0.35,0.39 and 0.45.From the result shown in the table, if the HD is less than 0.26,then False Rejection Rate(FRR) will be higher than 26.13% and if HD is greater than 0.45, the False Acceptance Rate(FAR) will go beyond 26.10%. Therefore, the optimum Hamming Distance operation for the CASIA data which concurrently minimizes both FAR and FRR stands at 0.39 where no enrolee was falsely accepted and 2.78% were falsely rejected i.e (legitimate users seen as imposters). This is corroborated with the graphs of figures 8 and 10. Also a perfect operating Hamming Distance for the black faces iris images, as shown in Table 2 was obtained at 0.45 where FAR = 0.57% and FRR = 0.33% (Here only 0.57% imposters are seen as legitimates and 3.33%

legitimates could not get recognition). This research work is very useful in an access control to places, organization and resources.

## 5 CONCLUSION

In this work, a more accurate way to detect the pupil and localize the iris of black people's face has been demonstrated (through the use of Circular Hough transform followed by Integro-differential operator and some morphological operations). Also, an accurate Hamming Distance for matching and recognizing iris image templates was obtained. Our result established that the optimum Hamming Distance needed to operate an iris recognition system with CASIA database is 0.39 which is not the same as that of the black iris images whose optimality was obtained at an hamming Distance of 0.45.(Table 2).

## 6 FUTURE WORK

A follow up to this research is the development of a black iris image websites that will be globally accessed like the other standard iris databases. It has the 150 black images used in this paper as version A while the B will have 1000 images from 100 subjects.

## 7 ACKNOWLEDGEMENT

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