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A Novel Iris Recognition System using Sobel Edge Detection and Binary coded features

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Abstract
Iris recognition is a form of biometric techniques that identifies user with the unique iris patterns between the pupil and the sclera. Biometric identification technology has been associated generally with very costly top secure applications. This paper suggests a new approach to iris recognition system. Sobel operator is used for iris edge detection. Simplicity and quickness of proposed edge detection method which is coping with binary images is considerable. Binary code representation from each iris image and a modified Hamming distance method is applied for matching process. Experimental results on UBIRIS.v1 images database which has 1877 images collected from 241 person's shows the reliability and efficiency of the proposed algorithm.

Keywords
Biometric identification, Iris recognition, Sobel, Hamming Distance, Image processing

1. Introduction
Biometrics technology using advanced computer techniques is now widely adopted as a front-line security measure for both identity verification and crime detection, and also offers an effective crime deterrent. Biometric techniques are used for the purpose of identifying individual by using unique characteristics of each person. A term derived from ancient Greek: 'bios' meaning 'life' and 'metric', 'to measure'. A biometric system can operate in two modes. One is Verification (authentication) which refers to the problem of confirming or denying a person's claimed identity (Am I who I claim I am?). Second is Identification (Who am I?) which refers to the problem of establishing a subject's identity either from a set of already known identities (closed identification problem) or otherwise (open identification problem).

The human iris (Figure 1) is rich in features which can be used to quantitatively and positively distinguish one eye from another. The iris contains many collagenous fibers, contraction furrows, coronas, crypts, color, serpentine vasculature, striations, freckles, rifts, and pits. Measuring the patterns of these features and their spatial relationships to each other provides other quantifiable parameters useful to the identification process. In practical terms, statistical analyses indicate that the Iridium Technologies IRT process uses 240 degrees-of-freedom (DOF), or independent measures of variation to distinguish one iris from another.

The availability of this many degrees of freedom allows iris recognition to identify persons with an accuracy that is orders of magnitude greater than other biometric systems.

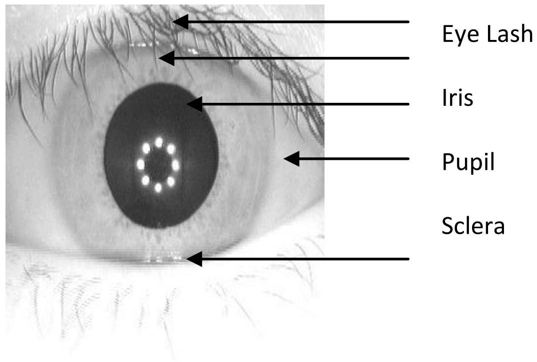

Figure 1 Typical Human Eye Image

The proposed system consists of various steps for iris recognition that include Edge Detection, Thresholding, Iris localization, Iris Normalization, Iris feature Extraction, Matching and then Results.

First an input gray scale eye image from UBIRIS.v1 is given to the system. After selecting the eye image, edge detection by Sobel operator, a spatial edge detection filter that detects edges by finding the gradient of an image. The Sobel operatory based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction. It is relatively inexpensive in terms of computations. Next step that includes iris segmentation which is done using Binary Thresholding and iris localization using Circular Hough Transform. Localized iris is then normalized using Daugman's Rubber Sheet Model. The feature vector is generated using a novel approach. In matching process, by comparing iris code with database, the modified Hamming distance method between each iris code and input code is adopted.

2. Edge Detection
The Sobel operator calculates the *gradient* of the image intensity at each point. By giving the direction of the largest possible increase from light to dark and the rate of change in that direction. The result therefore shows how "abruptly" or "smoothly" the image changes at that point, and therefore how likely it is that part of the image represents an *edge*, as well as how that edge is likely to be oriented. In practice, the magnitude calculation is more

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reliable and easier to interpret than the direction calculation.

The Sobel edge detector uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction (rows). A convolution mask is usually much smaller than the actual image. As a result, the mask is slid over the image, manipulating a square of pixels at a time. The actual Sobel masks are shown below:

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

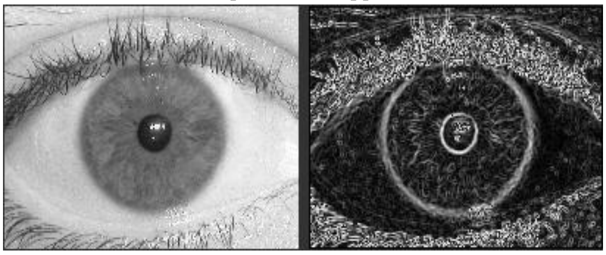
The magnitude of the gradient calculated by using the following formula:

$$|G| = \sqrt{G_x + G_y} \quad \ldots (1)$$

An approximate magnitude can be calculated using:

$$|G| = |Gx| + |Gy| \quad \ldots (2)$$

Figure 2 shows the input image and image obtained after the Sobel Operator applied to it.



(a) (b)

Figure 2 a) Input Gray Scale image b) Sobel Operator applied to the image.

3. Binary Thresholding

During the thresholding process, individual pixels in an image are marked as “object” pixels if their value is greater than some threshold value (assuming an object to be brighter than the background) otherwise as “background” pixels. This convention is known as *threshold above*. Variants include *threshold below*, which is opposite of threshold above. It was decided to select a threshold value as 128. (Figure 3) Typically, an object pixel is given a value “1” while a background pixel is given a value “0.”Finally, a binary image is created by coloring each pixel white or black, depending on a pixel’s labels.

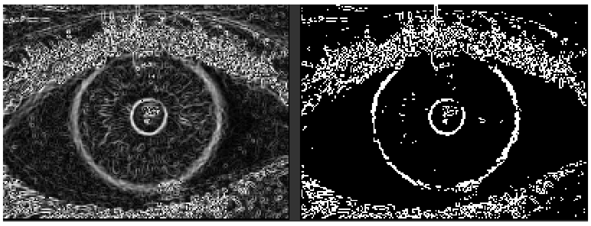
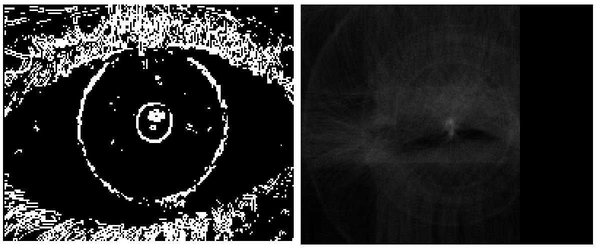


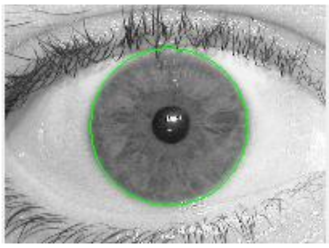
Figure 3.a) Edge detection using Sobel operator b) Image Thresholding

4. Iris Localization

At each edge point we draw a circle with center in the point with the desired radius. This circle is drawn in the parameter space, such that our x axis is the value and the y axis is the b value while the z-axis is the radii. The coordinates belong to the perimeter of the drawn circle. We increment the value in our accumulator matrix which essentially has the same size as the parameter space. In this way we sweep every edge point in the input image drawing circles with the desired radii and incrementing the values in our accumulator. When every edge point and every desired radius is used, we can turn our attention on accumulator. The accumulator will now contain numbers corresponding to the number of circles passing through the individual coordinates. Thus the highest numbers correspond to the center of the circles in the image.



(a) (b)



(c)

Figure 4 a) Sobel operator applied to the image. b) And c) Hough Transform

5. Iris Normalization

The homogenous rubber sheet model devised by Daugman remaps each point within the iris region to a pair of polar coordinates (r,θ). where r is the interval [0,1] and θ is angle [0,2π]. The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalized representation with constant dimensions. In this way the iris region is modeled as a flexible rubber sheet anchored at the iris boundary with the pupil Centre as the reference point.

For normalization of iris regions a technique based on Daugman's rubber sheet model. The Centre of the pupil was considered as the reference point, and radial vectors pass through the iris region, as shown in Figure 5. A number of data points are selected along each radial line and this is defined as the radial resolution. The number of radial lines around the iris region is defined as the angular resolution. Since the pupil can be non-concentric to the iris, a remapping formula is needed to rescale points depending on the angle around the circle.

A constant number of points are chosen along each radial line, so that a constant number of radial data points are taken, irrespective of how narrow or wide the radius is at a particular angle. Normalized pattern was created by backtracking to find the Cartesian coordinates of data points from the radial and angular position in the normalized pattern. From the 'doughnut' iris region, normalization produces a 2D array with horizontal dimensions of angular resolution and vertical dimensions of radial resolution. Figure 6 shows normalized iris means the output of Rubber Sheet Model implemented in our system.

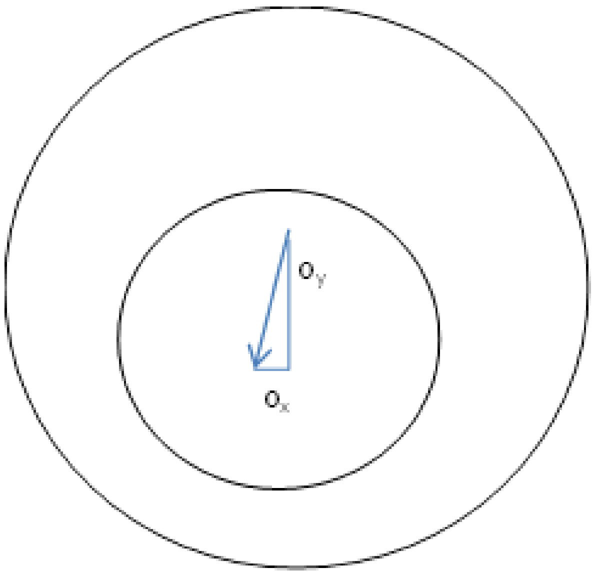
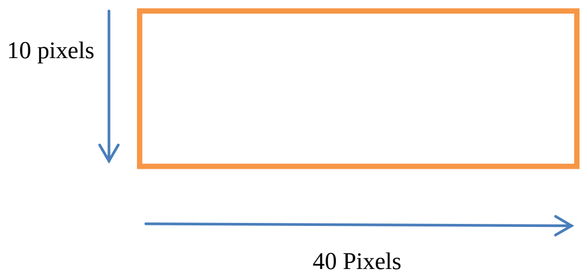


Figure 5 (a) Outline of the normalization process with radial resolution of 10 pixels, and angular resolution of 40 pixels.



(b)

Figure 5 (b) Pupil displacement relative to the iris center is exaggerated for illustration purposes.

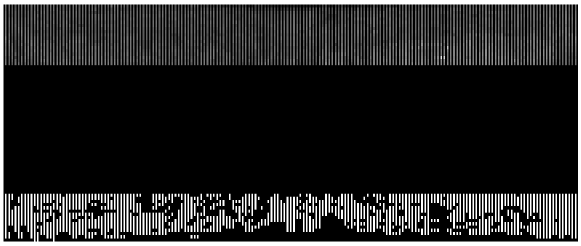


Figure 6 Normalized iris

6. Feature Extraction

"One of the most interesting aspects of the world is that it can be considered to be made up of patterns. A pattern is essentially an arrangement. It is characterized by the order of the elements of which it is made, rather than by the intrinsic nature of these elements". This system proposes a novel method for extracting features. A zero crossing is drawn on the strip and the point at which the crossing intersects with the strip that is assigned as 1 otherwise 0. Thus the binary coded feature vector is obtained.

7. Matching

Binary code of the test image is compared with each images of the database by using a modified Hamming distance method. The bits of both the images are forehand; if the result is 0 then a value +1 is assigned. Then next bits are XORED if again the result is 0 then 1 is added to +1, otherwise a new value -1 is assigned. A matching score is generated by adding these new values. If the matching score is compared with a threshold value and the best possible matching score of the trained image is considered for detecting a test user image. For our system, minimum matching scores i.e. threshold value is set as 650.

8. Results and conclusions

We tested our project on 25images and obtained an Average of correct recognition of 93%, with an average computing time of 31s. Table 1 gives the efficiency of each part of the system. The main reason of the failures we encountered is due to the threshold value of matching score.

	Edge Detection and binary thresolding	Iris Localization	Feature Extraction
Efficiency	98%	100%	100%

Twenty five eye images of 7 users are taken from UBIRIS.v1 iris database. One eye image has been used for enrollment and others for testing. At modified hamming distance threshold value 650 gives 0% false acceptance rate and 1.34% false rejection rate.

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