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# Human IRIS recognition and effect of compression on recognition system

**Mr.Milind B. Kadlag Mr. N. P. Sonawane**

***Abstract*— We investigate three schemes for severe compression of iris images in order to assess what their impact would be on recognition performance of the algorithms deployed today for identifying people by this biometric feature. Currently, standard iris images are 600 times larger than the Iris Code templates computed from them for database storage and search; but it is administratively desired that iris data should be stored, transmitted, and embedded in media in the form of images rather than as templates computed with proprietary algorithms. To reconcile that goal with its implications for bandwidth and storage, we present schemes that combine region-of-interest isolation with JPEG and JPEG2000 compression at severe levels, and we test them using a publicly available database of iris images. We show that it is possible to compress iris images to as little as 2000 bytes with minimal impact on recognition performance. Only some 2% to 3% of the bits in the Iris Code templates are changed by such severe image compression, and we calculate the entropy per code bit introduced by each compression scheme. Error tradeoff curve metrics document very good recognition performance despite this reduction in data size by a net factor of 150, approaching a convergence of image data size and template size.**

***Keywords* — Biometrics, image compression, image segmentation, iris recognition, JPEG2000, region of interest, receiver operating characteristic (ROC) curves.**

## I. INTRODUCTION

### A *Partial Iris*

The annular part between the pupil (generally black in an image) and the white sclera is the human iris, which has an extraordinary structure and provides many interlacing minute characteristics such as freckles, coronas, stripes, crypts and so on, which are called the texture of the iris and vary person to person.

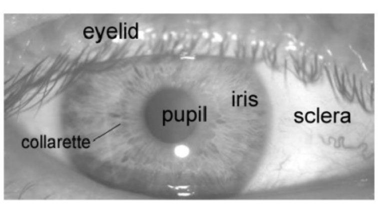


Fig.1.Different Iris Features

In traditional iris recognition systems the full iris image is taken for the collection of database images as well as the images to be matched. In these traditional methods many types of distortions present. The major distortion is due to the upper eyelid covering when collecting the iris images. Due to this major distortion this method uses the partial iris image instead of the full iris image. The lower part of the iris is selected for obtaining the feature vector. After forming the database of the images, the features of the images are extracted. This is done after the formation of feature vector. The feature vector is obtained after an iris-coding technique based on Gabor filter. Matching of the two iris images is done based on Hamming Distance. A threshold is set such that, if Hamming Distance between the two iris images is less than the threshold, then two irises belongs to the same person, otherwise not.

Data compression is one of several disciplines rooted in information theory having relevance to biometric technologies for identifying persons, and its significance extends beyond the practical matter of data-storage requirements. One of Shannon's fundamental insights in formulating information theory [1] was that the entropy of a random variable measures simultaneously its information content (expressed in bits) and its compressibility without loss (to the same number of bits). This link between entropy, informativeness, and compressibility extends also to other measures that apply to biometrics. For example, the relative entropy between two distributions is one way to measure how well a biometric technique separates samples from the same versus different people. The amount of variability in a given biometric across a population, or in different samples from the same source, is also captured by conditional entropies, with a larger entropy signifying greater randomness. Finally, the similarity between pairs of biometric templates is reflected by their mutual information: the extent to which knowledge of one sample predicts the other. All of these properties are deeply connected with the compressibility of biometric data.

## II. SIMPLE CROPPING AND JPEG COMPRESSION

An obvious first step to reduce the image data size from the standard iris image format of 640 X 480 pixels with 8-bit grayscale data per pixel, consuming 307 200 bytes, is to crop the image to a smaller region containing the iris, and then to JPEG compress this cropped image. We ran the eye-finding part of the standard algorithms [11] that are used in all current public deployments of iris recognition, on all images in the publicly available NIST [13] ICE1Exp1 database, which contains 1425 iris images from 124 subjects with "ground-truth" information given about which images were taken from the same iris. This database contains many images in which the iris is partly outside the full (640 480) image frame, or is severely defocused, occluded by eyelids or printed patterned contact lenses, interlace corrupted, or with the gaze of the eye directed away from the camera. The real-time algorithms for iris finding and encoding at video rates (30frames/s) have been described before in detail [11] and will not be reviewed again here. The algorithms correctly localized the iris in all images and produced from each one a new cropped image of 320 X 320 pixels with the iris centered in it. For those images in which the iris was partly outside the original image frame, the missing pixels were replaced with black ones. For those in which the algorithms detected that the gaze was directed away from the camera, as gauged by projective deformation of the eye shape, a corrective affine transformation was automatically applied, which effectively "rotated" the eye in its socket into orthographic perspective on-axis with the camera. Biometric recognition performance is usually measured by generating receiver operating characteristic (ROC) curves, which plot the tradeoff between two error rates false accept rate (FAR) and false reject rate (FRR] as the decision threshold for similarity scores is varied from conservative to liberal. It is common to tabulate specific points on such tradeoff curves, such as the FRR when the decision threshold causes an FAR of 1 in 1000 or of 1 in 10 000, and the point at which the two error rates are equal, FRR=FAR=EER, the equal error rate. Such ROC curves and tabulations are presented in Fig. 2 The JPEG quality factors (QF) studied here were 70, 30, and 20, producing cropped image file sizes averaging 12 400 bytes, 5700 bytes, and 4200 bytes (red, blue, and green ROC curves, respectively). Including the initial three-fold reduction in file size due merely to cropping the images to 320X320 pixels, these net data reduction factors relative to the original full-size images therefore average 25:1, 54:1, and 72:1, respectively. The red ROC curve in Fig. 2 shows that at a JPEG quality factor of 70 and an overall data reduction factor of 25:1, no performance loss relative to the baseline (black) ROC curve is detectable. (Indeed there is even some suggestion of a small benefit from compression, possibly due to denoising).

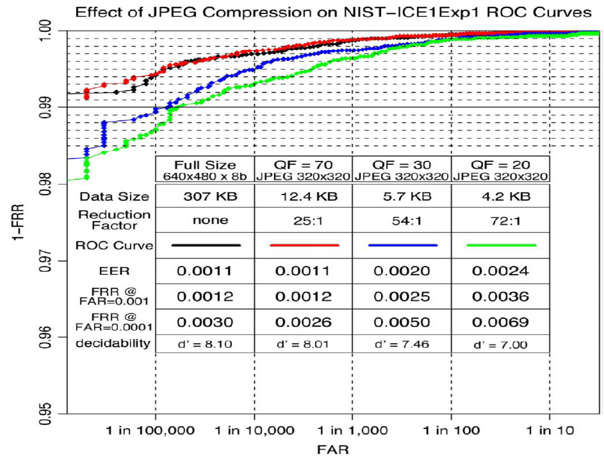


Fig.2. ROC curves

The blue and green ROC curves show that for this scheme based only on image cropping and JPEG compression, using a QF in the range of 20 to 30 produces image file sizes in the range of 5000 bytes but at the cost of roughly doubling the FRRs and EER. Clearly, one could do better by a form of cropping which extracted only the iris pixels, so that the JPEG compression did not waste bytes on noniris pixels. Iris templates are usually computed from a polar or pseudo polar coordinate mapping of the iris, after locating its inner and outer boundaries. However, both methods suffer from the fact that polar mappings depend strongly upon the choice of origin of coordinates, which may be prone to error, uncertainty, or inconsistency.

## III. Region-Of-Interest(roi) Segmentation

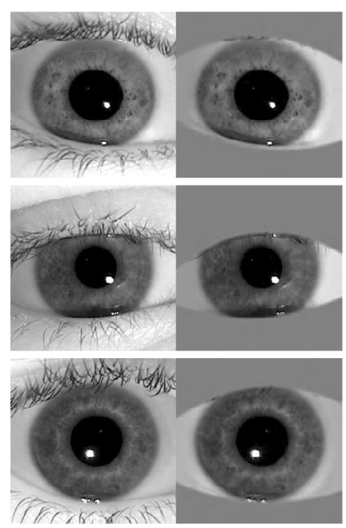

Fig.3. Region-of-interest isolation of the iris within rectilinear image array formats, to achieve greater compression

Image areas containing busy textures, such as eyelashes, may consume much of the available information budget. In uniform regions, the only nonzero discrete cosine transform (DCT) coefficient in each block of 64 frequency components that encode an 8X8 pixel block (data unit) is the dc coefficient specifying their average gray value; all other coefficients are 0 if the data
unit is a truly uniform region, or else become 0 after lossy quantization, and so their cost in the zeroes run-length coding stage is essentially nil. Therefore, JPEG encoding of iris images can be made much more efficient if all noniris parts of the image are
replaced with a uniform gray value. Such a substitution of pixel values within what is still a rectilinear image array is preferable, from the viewpoint of standards bodies, than actual extraction and mapping of pixel data from a normalized ("unwrapped") iris because it is desirable to be as shape agnostic and as algorithm
neutral as possible. This original rectilinear format is also preferable mathematically because pixels retain constant size and spacing, rather than suffering the polar size distortions and shift sensitivity of unwrapping method. JPEG coding schemes lend themselves well to the region-of-interest (ROI) differential assignment of the coding budget. Indeed the JPEG2000 standard [16]–[18], and even the Part 3 extension of the old JPEG standard [14], [15] support variable quantization for explicitly specifying different quality levels for different image regions. In JPEG2000, the MAXSHIFT tool allows specification of an ROI of arbitrary shape. This was explored for biometric face recognition by Hsu and Griffin [19], who demonstrated that recognition performance was degraded by no more than 2% for file sizes compressed to the range of 10 000–20 000 bytes with ROI specification. We now investigate how much compression of iris images can be achieved with minimal impact on iris recognition performance, using the ROI idea without "unwrapping" the iris but retaining a rectilinear array format. The impact of the ROI isolation and file size reduction on iris recognition performance is gauged by the ROC curves in Fig.4. These show that for each QF studied, iris recognition performance remained about the same as before the ROI isolation (Fig. 1), yet with an achievement of a further two-fold reduction in image data size, even down to the range of just 2000–3000 bytes per image.

## IV. JPEG 2000 COMPRESSION WITH ROI SEGMENTATION

In 2000, a more powerful version of JPEG coding offering more flexible modes of use, and typically achieving 20–30% further compression at any given image quality, was enshrined as the JPEG2000 Standard .

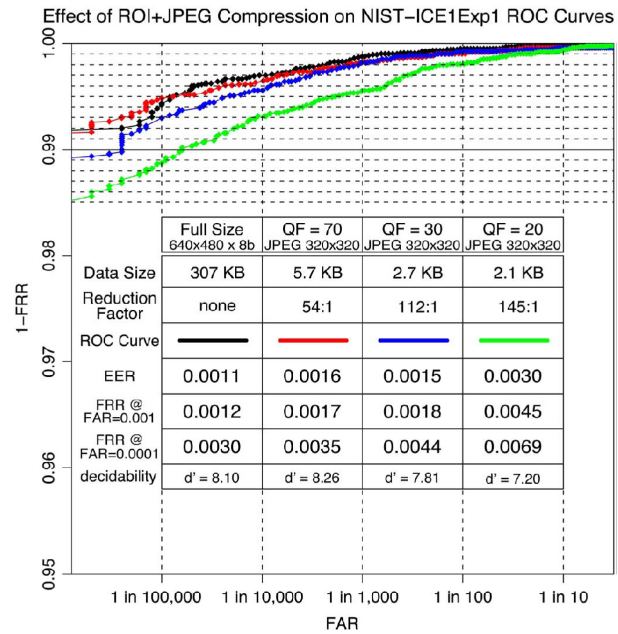

Fig.4. ROC curves and data-size statistics showing the consequences of ROI isolation before JPEG image compression

Mathematically based on a discrete wavelet transform (DWT) onto Daubechies wavelets rather than the DCT, JPEG2000 does not suffer as badly from the block quantization artifacts that bedevil JPEG at low bit rates, which are due to the fact that the DCT simply chops cosine waves inside box windows with obvious truncation consequences when they are sparse and incomplete. Moreover, the
different levels within the multi resolution DWT wavelet decomposition allow local areas within each image tile to be encoded using different sub-bands of coefficients. The net superiority of JPEG2000 over JPEG in terms of image quality is especially pronounced at very low bit rates, corresponding to severe compression, as we study here, in the range of 0.15 bits per pixel (bpp). Finally, JPEG2000 allows the use of a mask to specify an ROI of arbitrary shape to control the allocation of the encoding budget.

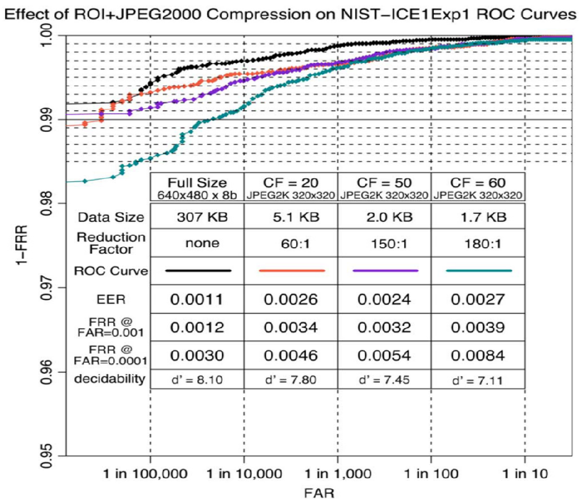


Fig.4. ROC curves and data-size statistics showing iris recognition performance when the cropped and ROI-isolated images are compressed using JPEG2000 at various compression factors.

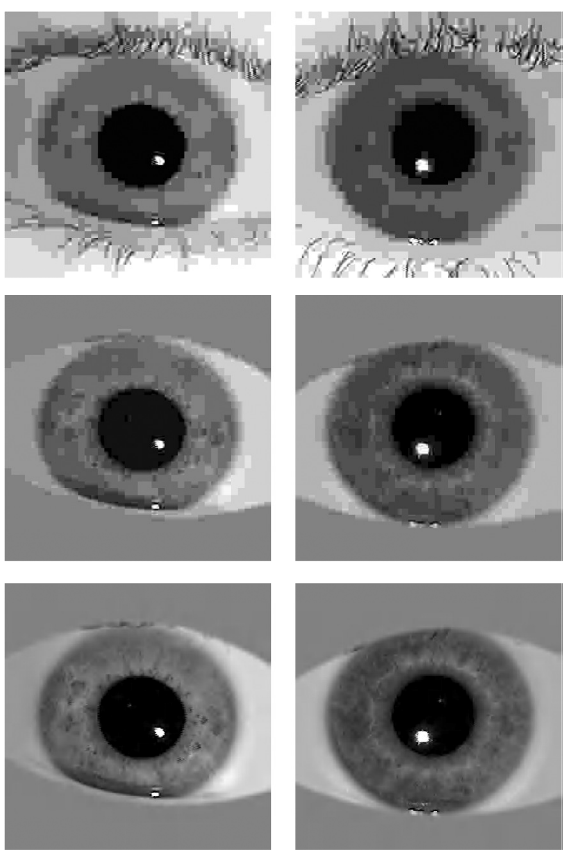

Fig.5. Visual comparison of the three schemes for iris image compression, for images all compressed to the same data size of 2000 bytes. The left column is NIST 239230; the right is NIST 239343. Top row: simple JPEG compression of the cropped (320X320) images. Middle row: JPEG compression of the cropped images after ROI isolation. Bottom row: JPEG2000 compression of the cropped and ROI-isolated images. Iris recognition performance of this third scheme is shown by the purple ROC curve

TABLE I

SUMMARY OF THE COMPRESSION SCHEMES, RESULTING FILE SIZES, AND THEIR EFFECTS ON COMPUTED IRISCODES, EXPRESSED AS ENTROPY PER CODE BIT AND AS THE FRACTION (HD) OF BITS THAT WERE CHANGED FROM THOSE COMPUTED FOR THE ORIGINAL FULL-SIZE IMAGES

| Strategy | Compression Parameter | Average Image Size | Entropy / code bit | Interopera-bility HD |
|---|---|---|---|---|
| Cropping (320×320) + JPEG Compression | QF = 70 | 12.4 kB | 0.053 bit | 0.006 |
| | QF = 30 | 5.7 kB | 0.087 bit | 0.011 |
| | QF = 20 | 4.2 kB | 0.147 bit | 0.021 |
| Cropping + ROI + JPEG Compression | QF = 70 | 5.7 kB | 0.112 bit | 0.015 |
| | QF = 30 | 2.7 kB | 0.147 bit | 0.021 |
| | QF = 20 | 2.1 kB | 0.199 bit | 0.031 |
| Cropping + ROI + JPEG2000 Compression | CF = 20 | 5.1 kB | 0.130 bit | 0.018 |
| | CF = 50 | 2.0 kB | 0.179 bit | 0.027 |
| | CF = 60 | 1.7 kB | 0.219 bit | 0.035 |

## CONCLUSION

We have studied the effects of three schemes for image compression on iris recognition performance, leading to the surprising conclusion that even images compressed as severely as 150:1 from their original full-size formats, to just 2000 bytes, remain very serviceable. It is important to use region-of-interest isolation of the iris within the image so that the coding budget is allocated almost entirely to the iris; and it is important to use JPEG2000 instead of JPEG as the compression protocol. Advantages of this overall approach from the perspective of standards bodies and interoperability consortia are that the compact image data (when decompressed) is a native rectilinear array; no proprietary methods are required; and the distortions that can arise from alternative coordinate transformation methods such as polar unwrapping or polar sampling are avoided.

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## AUTHOR'S PROFILE

| | |
|---|---|
| Passport Size Latest Color Photo | **Mr. Milind Baban Kadlag**<br>M.E. E&TC<br>milind.kadlag@gmail.com<br>milind_kadlag@rediffmail.com |

| | |
|---|---|
| Passport Size Latest Color Photo | **Prof. M. A. Shahzad**<br>M.E. E&TC<br>SRES's College of Engineering, Kopargaon. |

| | |
|---|---|
| Passport Size Latest Color Photo | **Mr. N.P. Sonawane**<br>M.E. E&TC<br>npsonawane@gmail.com |