Iris Image Quality Assessment for Biometric Application

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Abstract — Image quality assessment plays an important role in the performance of biometric system involving iris images. Data quality assessment is a key issue in order to broaden the applicability of iris biometrics to unconstrained imaging conditions. In this paper, we have proposed the quality factors of individual iris images by assessing their prominent factors by their scores. The work has been carried out for the following databases: CASIA, UBIRIS, UPOL, MMU and our own created COEP Database using HIS 5000 HUVITZ Iris Camera. The comparison is also done with existing databases which in turn will act as a benchmark in increasing the efficiency of further processing.

Keywords – Biometrics, iris, image quality assessment, quality factor, segmentation, iris recognition.

1. Introduction

Security and authentication of individuals is a necessity rather than need in our lives in the modern day, with most people having to authenticate their unique identity on a daily basis; examples include ATMs, secure access to buildings in their work place and so on. Biometric identification provides a valid alternative to traditional authentication mechanisms such as ID cards and passwords [12], [13].

Iris recognition is a particular type of biometric system that can be used reliably in identifying a person by analyzing the patterns found in their iris [10], [11], [6]. The iris is so reliable as a form of identification because of the uniqueness of its pattern. In this paper, we introduced a comprehensive approach to assess quality of iris images.

2. Factors Affecting Iris Images

There are many factors which may affect the quality of the iris images. Images usually get affected from wide range of qualities like dilation, specular reflection, iris resolution, motion blur, camera diffusion, presence of eyelids and eyelashes, head rotation, camera angle, contrast, luminosity etc. Researchers like John Daugman, Hugo Proenca, J. Zuo, N. Kalka and N. Schmid, etc. have given some propositions on iris quality assessment [1], [2] [3], [4], [5] [6]. More recently, Daugman employs a quality metric that combines global and local analyses to measures defocus, motion (interlacing), occlusion to improve iris recognition performance [8]. The major drawback of most existing approaches is that evaluation of iris image quality is reduced to estimation of a single or a pair of factors such as defocus blur, motion blur, and/or occlusion [7]. Moreover, the majority of the work has been carried out only over a few free available databases [10], [11]. In accordance to this, nine quality factors such as Dilation Measure (DM), Ideal Iris Resolution(IIR), Actual Iris Resolution (AIR), Processable Iris Resolution (PIR), Signal to Noise Ratio (SNR), Occlusion Measure (OM), Specular Reflection (SR), Eccentric Distance Measure (EDM), Angular Assessment (θ) have been assessed in this paper. Also the analysis has been carried over four free available databases, i.e. CASIA, UBIRIS, MMU, UPOL and our own database named COEP.

3. Implementation of Algorithms for Estimating the Quality Factors

Localization:

Daugman's recognition algorithm is used in all or nearly all current commercial iris recognition systems. Indeed, the integro-differential operator for circular edge detection, and the pseudo-polar coordinate transform, which are two of the image pre-processing steps introduced by Daugman in his first papers on this topic, have been incorporated into various other proposed recognition methods. Therefore it is necessary to begin this section with the Daugman segmentation method [14]. To obtain a first approximation to the pupil boundary, limbic boundary, and eyelid boundary,

$$\max(r, x_0, y_0) \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} \partial s \right| \quad (1)$$

the integro-differential operator is applied, where I(x,y) are the image grayscale values, $G_\sigma(r)$ is a smoothing function such as a Gaussian of scale σ, and the contour integral is along circles given by center (x_0, y_0)and radius r. This operator finds the maximum blurred partial derivative of the image grayscale values with respect to a radial variable, of a contour integral along circles when searching for the pupil and limbic boundaries, and is modified to search along arcs for eyelid boundaries.

3.1 Dilation Measure:

The dilation of a pupil can affect the recognition accuracy. If the iris is too dilated, there is a possibility of losing the information which may not serve the adequate necessary information for recognition.

The dilation measure (D) is calculated by

$$D = \frac{PupilRadius}{IrisRadius} \times 100 \qquad (2)$$

3.2 Occlusion Measure:

The occlusion measure (O) is to measure how much percentage of the iris area is invalid due to eyelids, eyelashes, and other noise. The total amount of available iris pattern scan decides the recognition accuracy.

$$O = \frac{Invalid\ area\ in\ the\ segmentation\ mask}{Segmentation\ mask\ size} \times 100\% \qquad (3)$$

3.3 Specular Reflection:

Once eyelid occlusions are estimated, occlusions resulting from specular reflection are evaluated on the remaining iris portion unaffected by the eyelids.

$$Specular\ Reflection = \frac{Output\ image\ area\ pixel\ count}{Input\ area\ image\ pixel\ count} \times 100\% \qquad (4)$$

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3.4 Ideal Iris Resolution:

It is the resolution of the iris obtained ideally in the absence of noise. Ideal Iris Resolution (IIR) can be calculated by given formula

$$IIR = \text{Iris area} - \text{Pupil Area} = \pi\,(R_i^2 - R_P^2) \qquad (5)$$

Where R_i is radius of Iris and R_P is radius of Pupil

3.5 Actual Iris Resolution:

It is the resolution of the iris obtained in the presence of noise like eyelid, eyelash. Actual Iris Resolution (AIR) is calculated as below.

AIR = Iris Area - (Pupil Area + Eyelid + Eyelash) (6)

This can give the visible iris which can be processable for further application.

3.6 Processable Iris Resolution:

It is the available part of iris from which features can be extracted for further processing and the ratio of Actual Iris Resolution (AIR) to Ideal Iris Resolution (IIR) will give the Processable Iris Resolution (PIR).

$$PIR = \frac{AIR}{IIR} \qquad (7)$$

3.7 Occlusion Measure:

The presence of Eyelid and Eyelid in combination is given as Occlusion. The Occlusion Measure (OM) is to measure how much percentage of the iris area is invalid due to eyelids, eyelashes, and other noise. The total amount of available iris pattern scan decides the recognition accuracy. Occlusion Measure is calculated by given formula

$$OM = \frac{eyelid + eyelash}{IIR} \qquad (8)$$

3.8 Signal to Noise Ratio:

The Signal to Noise Ratio (SNR) should be as high as possible. Ideally it should be infinite considering the fact that ideally noise is taken as zero. Moreover, in real time cases due to the presence of noises it is not so. But is actually very low and differs from database to database. As far as the noise is low SNR will be very high.

SNR is calculated as follow:

$$SNR = \frac{AIR}{OM} \qquad (9)$$

3.9 Eccentric Distance measure:

The position of Iris and Pupil with respect to each other is estimated by measuring the distance between the coordinates of their centers Eccentric Distance Measure (EDM) is calculated as follow

$$EDM = \sqrt{(Y_i - Y_P)^2 + (X_i - X_p)^2} \qquad (10)$$

Where, (X_i, Y_i) is the coordinate of Iris center

(Xp, Yp) is the coordinate of Pupil center

3.10 Angular Assessment:

The placement of the pupil on iris and the evaluation of the sector of iris is achieved by determining the angle (θ) between these both.

$$\theta = tan^{-1}\frac{Y}{X} \qquad (11)$$

Where $Y = Y_i - Y_P$

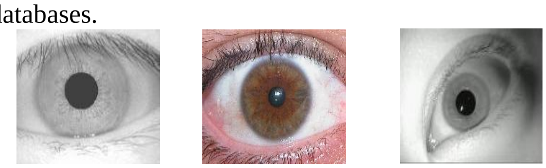
$X = X_i - X_p$

(X_i, Y_i) is the coordinate of Iris center

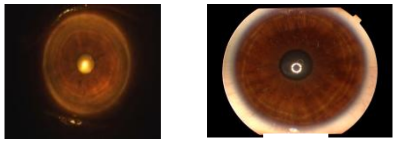
(Xp, Yp) is the coordinate of Pupil center

4. Various Stages of Processed Iris Images

In order to determine the quality factors, the images for implementing the algorithm have been used from free available databases such as Chinese Academy of Science, Institute of Automation (CASIA), University of Beira Interior (UBIRIS), Multi Media University (MMU), College of Engineering, Pune (COEP), University of Palack'eho and Olomouc (UPOL). Fig. 1 shows sample images from the above databases.



(a) (b) (c)



(d) (e)

Fig.1. Sample iris images from various databases such as (a) CASIA, (b) UBIRIS, (c) MMU, (d) COEP, (e) UPOL

Fig. 2 highlights various processing steps implemented in order to find out various quality factors. Fig. 2 (a) shows the original image from CASIA. Contrast enhancement is done in order to determine boundary of iris as well as pupil using circular edge detection algorithm. Fig. 2 (b) and 2 (d) shows contrast enhanced image for circular edge detection for iris and pupil respectively. Fig. 2 (c) and Fig 2 (e) shows circular edge detection for iris and pupil respectively. Fig. 2 (f) shows the Ideal Iris Resolution which is implemented by the method shown above; whereas Fig. 2 (g) and Fig. 2 (h) indicate eyelash, pupil, and eyelid respectively which is detected by thresholding. Fig. 2 (i) represents the Actual Iris Resolution.

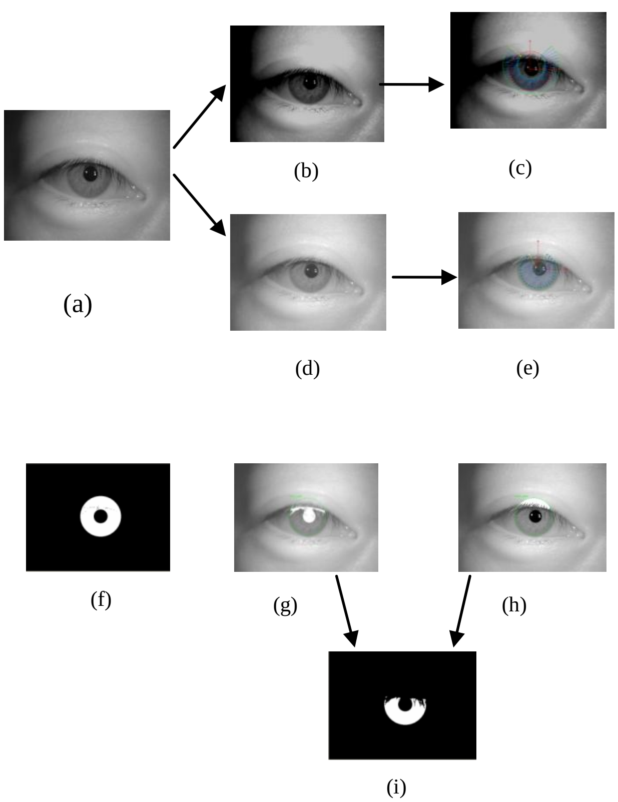


Fig.2 Various stages of processed iris images

5. Results

The variation in Dilation Measure for different databases is represented in Fig 3. The UPOL database has low variation in dilation measure while CASIA indicates high variation.

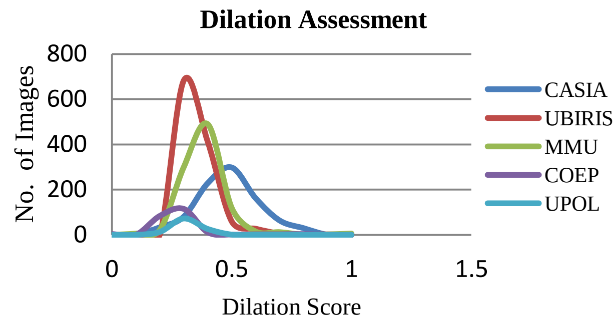


Fig.3. Dilation score analysis

The variation in Processable Iris Resolution for different databases is represented in Fig 4. The UPOL database has high PIR score while CASIA has low PIR score.

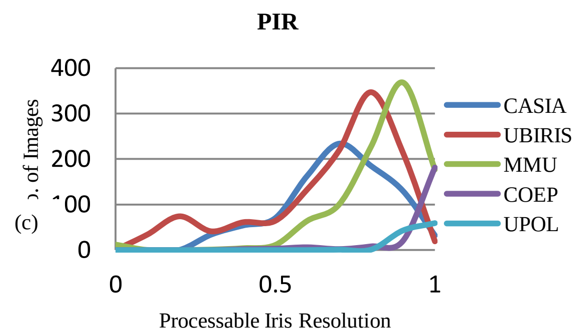


Fig.4. PIR Assessment

The variation in Occlusion Measure for different databases is represented in Fig 5. From the Fig. 5 it is clear that UBIRIS and CASIA databases show high presence of Occlusion whereas UPOL and COEP show less occlusion presence.

The variation in Eccentric Distance Measure for different databases is represented in Fig. 6.The UBIRIS database has low variation in Eccentric Distance Measure while CASIA and COEP indicates high variation.

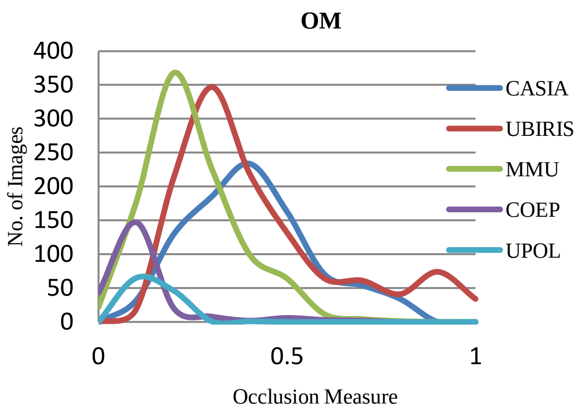


Fig.5. Occlusion score analysis

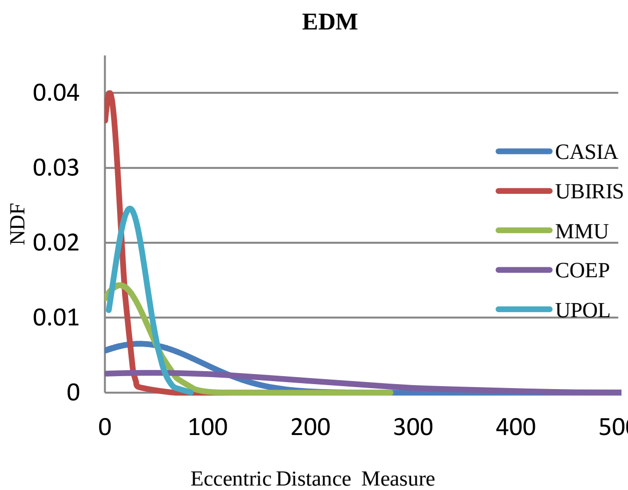


Fig.6. Eccentric Distance Measure

The variation in Angular Measure for different databases is represented in Fig. 7. The databases MMU, CASIA and COEP have similar range in angular measure whereas UBIRIS has negative angles high in number and UPOL has a moderate range.

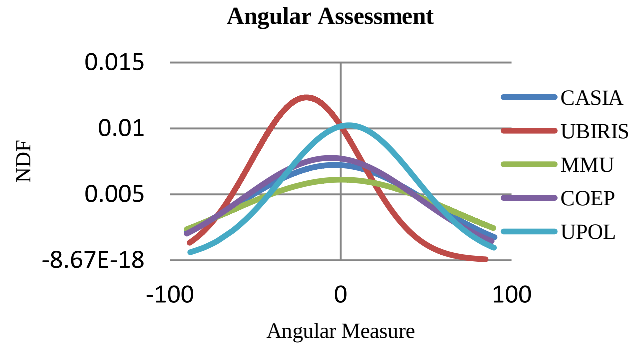


Fig.7.Angular Measure

Table I shows comparison of quality scores for various databases.

6. Conclusion

In this paper, the estimation procedure for Ideal Iris Resolution, Actual Iris Resolution, Process able Iris Resolution, Occlusion Measure, Signal to Noise Ratio, Eccentric Distance Measure, and Angular Assessment is discussed. We also conclude that the factors will affect further processing part adversely if their score is not at par. By evaluating their scores, it can be titled as an image which is eligible or not for further processing. This can also serve as a tool to comment about the quality of images in a database in turn the quality of the database images. The iris quality assessment module may be integrated with other modules in iris recognition system.

7. References

[1] N. Kalka, J. Zuo, N. Schmid and B. Cukic., "Image quality assessment for iris biometric,"*Proceedings of SPIE - The International Society for Optical Engineering*, v 6202, 2006, Biometric Technology for Human Identification III, May 2010.

[2] A. Abhyankar and S. Schuckers, "Iris quality assessment and bi-orthogonal wavelet based decoding for recognition," *Pattern Recognition*, vol. 42, pp. 1878–1894, 2009.

[3] Hugo Proença, "Quality Assessment of Degraded Iris Images Acquired in the Visible Wavelength," *IEEE Trans. on Information Forensics and Security*, vol. 6, no.1, March 2011.

[4] X. Zhu, Y. Liu, X. Ming, and Q. Cui, "A quality evaluation method of iris images sequence based on wavelet coefficients in 'region of interest," *Proc. of the 4th Int'l Conf. on Computer and Information Technology*, pp. 24–27, September 2004.

[5] Y. Chen, S. Dass, and A. Jain, "Localized iris quality using 2-D wavelets," International Conference on Biometrics, pp. 373–381, 2006, Hong Kong, China.

[6] L. Ma, T. Tan, Y. Wang, and D. Zhang, "Personal identification based on iris texture Analysis," *IEEE Trans. on Pattern Analysis and Machine Intelligence* 25, pp. 1519–1533, December 2003.

[7] B. Kang and K. Park, "A study on iris image restoration," *Proc. Audio and Video-Based Biometric Person Authentication* 3546, pp. 31–40, July 2005.

[8] J. Daugman, "How iris recognition works," *IEEE Trans. on Circuits and Systems for Video Technology"* vol.14, pp. 21–30, January 2004.

[9] C. Shi and L. Jin., "A fast and efficient multiple step algorithm of iris image quality assessment," *Proceedings of the 2010 2nd International Conference on Future Computer and Communication,* ICFCC 2010, v. 2, pp. 2589- 2593, 2010 .

[10] R. Wildes, "Iris recognition: An emerging biometric technology", *Proceedings of the IEEE*, pp. 1348 –1363, September 1997.

[11] W. Boles, B. Boashash, "A human identification technique using images of the iris and wavelet transform," *IEEE Transactions on Signal Processing*, vol. 46, no. 4, 1998.

[12] Y Ping Huang, "An Efficient Iris Recognition System," *First International Conference on Machine Learning and Cybernetics, Beijing*, 4-5 November 2002.

[13] T. Camus and R. Wildes, "Reliable and Fast Eye Finding in Close-up Images," *16th International Conference on Pattern Recognition*, vol. 1, pp. 389-394, 2002.

[14] J. Daugman, How iris recognition works?, *IEEE Transactions on Circuits and Systems for Video Technology* vol. 14 no. 1, pp. 21-30, 2004.

Table I. Comparison of estimated quality scores for various databases

Database / Quality Score	CASIA		UBIRIS		MMU		COEP		UPOL	
	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.
Dilation Measure	0.4366	0.1303	0.3222	0.2108	0.36	0.298	0.283	0.3519	0.2607	0.0529
IIR	33838.4	40589.9	6165.9	690.3	11300.93	21639.6	256564.8	287577.9	206981.5	49794.26
AIR	18117.43	14001	3804	1374.58	9895.879	18595.24	239962.6	287686.6	188326.6	41441.1
PIR	0.6449	0.1632	0.62	0.221	0.8179	0.56	0.94945	0.15377	0.9135	0.0698
Occlusion Measure	0.355	0.1632	0.3793	0.2216	0.182	0.56	0.05	0.1537	0.0864	0.0698
Eccentric Distance Measure	33.877	61.113	4.898	9.984	14.498	27.877	40.129	143.318	24.286	16.2315
Angular Assessment	-3.413	55.27	-19.942	33.339	0.5705	65.311	-5.258	50.944	4.8015	38.975