Image Quality Assessment for Iris Biometric

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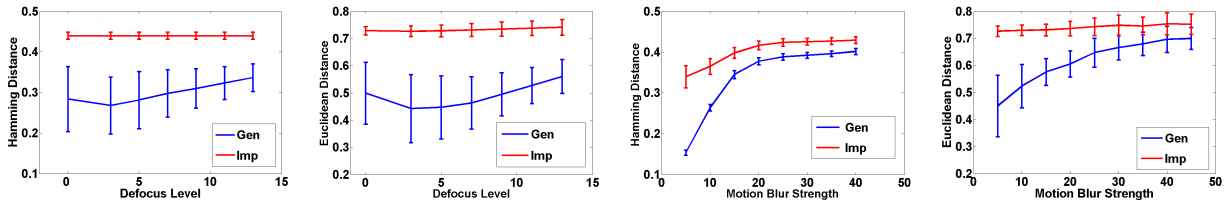
1. Introduction

Image quality assessment plays an important role in automated biometric systems for two reasons: (i) system performance and (ii) interoperability. In this paper we assess image quality from the iris biometric. We study the impact of various factors on performance as well as evaluate which factors can be feasibly compensated. There has been no extensive study on iris image quality from a system performance perspective, though such studies exist for biometrics such as fingerprints [4, 5]. Previous works in iris literature focus on one or two quality factors [2, 6]. In this work, we explore a range of causes from sensor-oriented noises to user oriented noises which often degrade image quality.

2. Methodology and Simulated Results

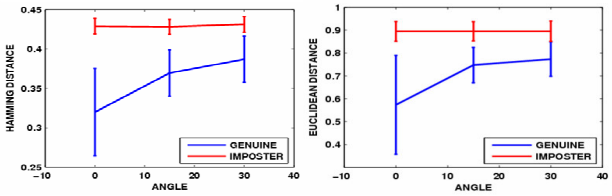
This section outlines the test procedures followed within this study. Of all the publicly available databases, none provides sufficient data to test our quality factors. For this reason, we took a subset of the CASIA dataset [1] which had better quality images (28 images were manually selected) and synthetically degraded the image quality based on individual factors described below. Then we encoded images using two approaches: Gabor filter based [2], and the global Independent Component Analysis (ICA) based [3]. Two measures, Hamming distance and Euclidean distance, associated with the two encoding approaches were used to quantify the recognition performance. During performance evaluation, good quality images were used for training while degraded images were used for testing. We found that three factors: Defocus, Motion, and Off-Angle to substantially degrade performance more than the other quality factors (occlusion, pupil dilation, illumination, pixel counts, and specular reflection). In this abstract, we show results only for these three factors.

Defocus Blur: To simulate this factor we apply a low pass Gaussian filter. Fig. 1 shows the dependence of distance



(a) Gabor (b) ICA (c) Gabor (d) ICA

Fig. 1. Effect of Defocus (a) and (b) and Motion (c) and (d) blur using different encoding methods.



(a) Gabor (b) ICA

Fig. 2. Effect of out of plane images (off-angle) on different encoding methods.

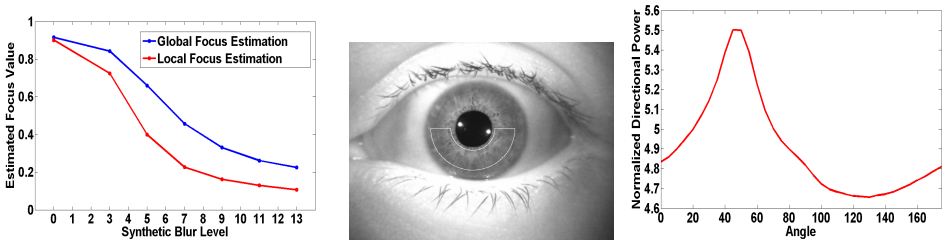
measures on the strength of defocus (subplots (a) and (b)) and motion blur (subplots (c) and (d)). Each of four panels in Fig. 1 displays two bar plots, the genuine matching score as a function of the blur strength (the bottom plot) and the imposter matching score as a function of the blur strength (the upper plot). Performance degrades as blur level increases ("gen" and "imp" also marked in blue and red in Fig. 1 refer to genuine and imposter scores, respectively). Low blur levels denoise image whereas high blur levels suppress high frequency image content and hence result in the degradation of performance. Defocus level corresponds to the width of the Gaussian kernel varied from (1 - 13).

Motion Blur: This factor is simulated by linearly modeling two parameters: direction of smear and pixel-smear amount. Motion strength corresponds to the length of the blur in pixels varied in the range (1 - 50). Fig. 1 (c) and (d) show that even small amounts of motion blur significantly degrades performance independent of angle (In Fig.1, the smear direction is 0 degrees).

Off-Angle: This factor was tested using a dataset collected at WVU with 200 iris classes, four images per iris class including 2 frontal view, one image presumably acquired at 15 degree view and the other image presumably acquired at 30 degree view. This factor is compensated by using an exhaustive projective transform. Fig. 2 shows that an increase in out of plane rotation decreases the separation of scores. The angles shown in Fig. 2 (i.e. 0, 15, and 30) were roughly known during data collection.

3. Estimation of Quality Factors

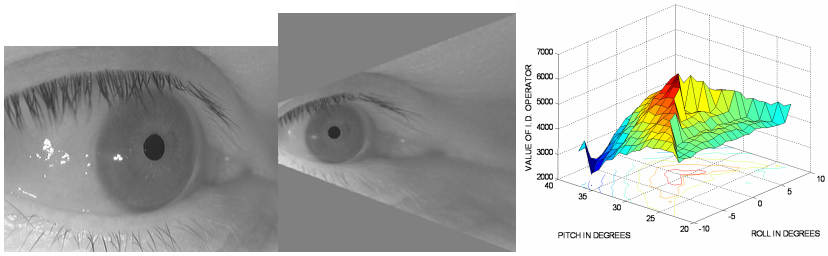
Defocus is assessed by measuring high frequency content in the overall image or segmented iris region similar to [2] or using a technique as described in [6]. The estimated defocus quality measure is a scalar between (0 - 1), representing low to high focus respectively. Shown in Fig. 3 (a) is a plot of the global and local focus estimation as functions of synthetic blur level. An example of the local patch is shown in Fig 3 (b). The plot is intuitive: as blur increases, our defocus operator decreases for both local and global assessments. The local assessment is more sensitive than the global measure, which is expected because it primarily contains mid to high frequency iris texture that surrounds the pupil. Local assessment is extremely viable when iris images are not canonical and as a result, high frequency content such as eyebrows or eyelashes will not attenuate the focus score.



(a) Global and Local Estimation (b) Local Focus Patch (c) Synthetic angle is 40. Estimated angle is 45.

Fig. 3. (a) and (b) Estimation of Global/Local Focus. (c) Motion blur angle estimation.

Motion blur is detected by analyzing directional properties of the frequency spectrum of the image. This is accomplished by applying directional masks over 36 equal-spaced orientations between (0 - 179) in either Fourier or Wavelet domains. The total power of each mask is then computed and the mask with maximum power is taken as the estimated angle. Fig. 3 (c) is a plot of normalized total power for each mask from an iris image synthetically blurred at 40 degrees. The estimated angle in this instance was 45 degrees. Motion strength estimation is currently being evaluated by examining a "slice" of Fourier coefficients perpendicular to the estimated angle. This process is still being researched and is a part of the ongoing work. Out-of-plane rotation is estimated by projectively transforming an off-angle image back into frontal



(a) Off-angle image at 30 degrees. (b) Rectified image (c) Operator value vs. pitch and roll

Fig. 4. Off-angle estimation.

view. To estimate the angle of rotation we assume an initial rough estimate is known. The optimal estimate would be exhaustively searched over all possible angles for pitch and roll. Daugman's integro-differential operator as a measure of circularity (one image scenario) or Hamming distance (multiple image scenario with at least one frontal view image) can be used as the objective functions as described in [3]. Estimates are chosen such that Hamming distance is minimized and integro-differential operator is maximized. Shown in Fig. 4 is an off-angle image (a) roughly known at 30 degrees is rectified (b) by projectively transforming the image over various pitch and roll angles. Fig. 4 (c) shows a 3D-plot of the integro-differential operator as a function of pitch and roll for this transformation.

Other factors such as occlusion, illumination, pupil dilation, specular reflection and pixel counts are still being evaluated. The correlation between these different factors is also being evaluated, with the intent of fusing all scores between the different quality factors into a combined metric.

References

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