Comparison of Compression Algorithms' Impact on Iris Recognition Accuracy

Stefan Matschitsch[1], Martin Tschinder[1], and Andreas Uhl[1,2]
[1]School of Telematics & Network Engineering, Carinthia Tech Institute, Austria
[2]Department of Computer Sciences, Salzburg University, Austria
Contact author e-mail: uhl@cosy.sbg.ac.at

Abstract

The impact of using different lossy compression algorithms on the matching accuracy of iris recognition systems is investigated relating rate-distortion performance to the matching scores obtained by a concrete recognition system. JPEG2000 and SPIHT are found to be well suited for the compression task, followed by PRVQ, JPEG, and finally FRAC. Overall, applying compression algorithms is found to increase FNMR but does not impact FMR. Thus "only" user convenience is reduced leaving security of iris recognition systems unchanged.

Introduction

Compression technology may be used in two stages of the processing chain in classical biometric recognition:

1. **Storage of reference data:** In order to avoid re-enrollment after feature replacement, not only features required for the current matching technique, but original sensor data needs to be stored in compressed form (to save storage space). This is useful, when e.g. superior or licence-free matching techniques involving different feature sets become available.
2. **Transmission of sample data after sensor data acquisition:** In order to support dislocated data acquisition by potentially low power devices (not capable of more demanding feature extraction) sensor data has to be compressed to minimize the amount of data to be transferred by e.g. wireless channels with low bandwidth.

Iris Image Compression

Recent standard ISO/IEC 19794-6 on Biometric Data Interchange Formats allows iris data to be stored in lossy manner in JPEG and JPEG2000 formats. This work aims at evaluating the application of several different general purpose compression algorithms in a 1-D version of the Daugman iris recognition system. Since compression artifacts may interfere with feature extraction and may degrade matching results, not only PSNR or RMS-errors are investigated, but the tradeoff between compression ratio and effects on actual matching (FRR will increase, since features are extracted less accurately - in extreme cases, even FAR might be affected) is analyzed.

Experimental Study

Setting and Methods

We use the following five different image compression algorithms:

Algorithm (Implementation)	Description
JPEG	block-DCT based standard
JPEG2000 (http://jj2000.epfl.ch)	wavelet-based standard
SPIHT (http://www.cipr.rpi.edu/research/SPIHT)	zero-tree based codec
FRAC (http://www.verrando.com/~verrando/pulcini/gp-ifs1.html)	fractal image compression
PRVQ (http://www.ganesh.org/webcomp/images)	vector quantization

The employed **Daugman-based iris recognition system** is Libor Masek's Matlab Implementation[a], whose feature extraction relies on strongly quantized phase responses of complex 1-D Gabor filters considering translation, rotations and disturbed regions in the iris (a noise mask is generated). Matching between two extracted feature vectors is based on hamming distance reaching from zero (ideal match) to 0.5 (ideal mismatch).
For all our experiments we considered 8-bit grayscale **CASIA[b] 1.0 images**, which were cropped to square size of 280×280 pixels for compression software compatibility reasons. Depending on whether compression is employed to store reference data only, or the sample data acquired for verification is compressed (e.g. for efficient transfer), or both, matching involves either just one compressed image or two compressed images. Therefore, we use both settings in our experiments.

[a] http://www.csse.uwa.edu.au/~pk/studentprojects/libor/sourcecode.html
[b] http://www.sinobiometrics.com

Experimental Results

Effect of compression on iris detection

ISO/IEC 19794-6 specifies two types of images:

- **polar images** containing basically the result of iris detection and segmentation, and
- **rectilinear images**, i.e. images of the entire eye.

We concentrated on the latter in order to examine the effect of compression on iris detection and determination of noise masks. As can be seen in Fig. 1 (showing a pair of original and JPEG2000 rate 96 compressed iris images together with extracted iris templates and noise masks of one person) we experienced:

- **differences in the template are more significant** as those in the noise masks, and,
- **iris detection is very robust** to compression (except for FRAC in case of a compression rate > 20).

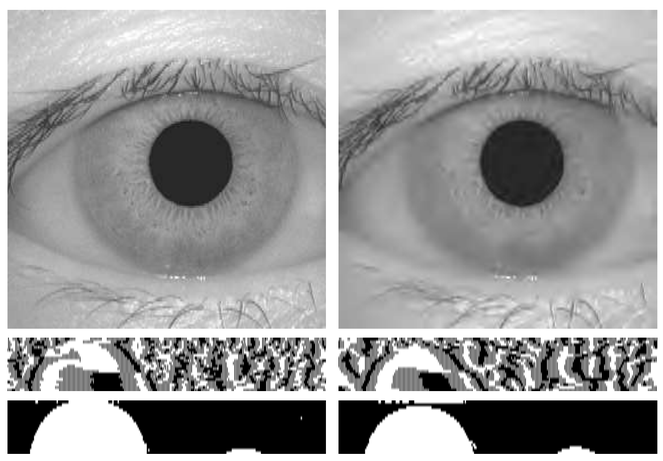


Fig. 1 Comparison of uncompressed/compressed iris image and the corresponding iris templates and noise masks.

Rate-distortion performance

As can be seen from Fig. 2 showing the average rate-distortion comparison of the different compression algorithms applied to all iris images, JPEG2000, SPIHT and PRVQ could be most suitable in iris recognition.

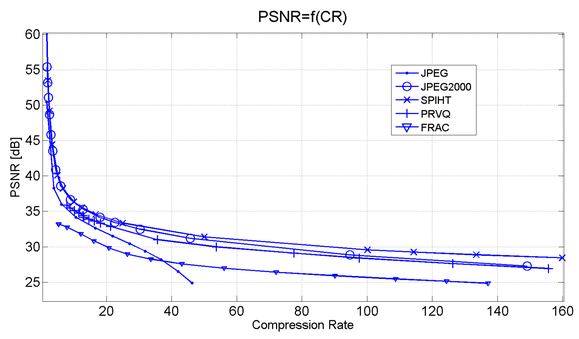
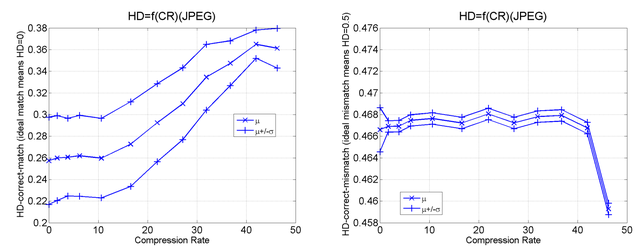


Fig. 2 Comparison of rate distortion of different compression algorithms.

Impact of JPEG compression on matching scores

The effect of JPEG compression applied to iris images on matching score results obtained in hamming distance (HD) is depicted in Fig. 3. Mean HD and mean standard deviation are plotted as functions of compression rate. Obtained results are as follows:

- Mean HD values stay constant at 0.26 until compression rate exceeds 10 with a mean standard deviation of 0.04.
- Selected decision threshold $t = 0.32$ HD (an interval of $0.26 \leq t \leq 0.35$ is discussed as the border between match and mismatch in iris recognition) is crossed at a compression rate of 28.
- For the case of imposters, HD remains above 0.45 with low deviation (0.01) across the whole range of compresion rates.



(a) legitimate users (b) imposters

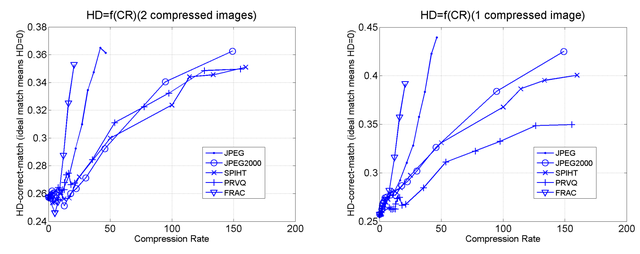
Fig. 3 Impact of JPEG compression on iris recognition, 2 compressed images.

General trend of other compression schemes is almost identical with respect to standard deviations and concerning the absence of false positive matches. For this reason we concentrate on analyzing compression impact on correct matches - legitimate users.

Comparing compression impact on genuine matching scores

Inspecting the performance of other tested algorithms for genuine users in Fig. 4, it can be seen that:

- **PSNR is generally a good predictor for matching performance** with compressed iris images. Superiority of JPEG2000, SPIHT and PRVQ (crossing the 0.32 border at a compression rate of about 80-90) is even more significant as suggested by PSNR. However, even though PSNR values suggest FRAC to be superior to JPEG for compression rates > 36, iris detection fails for FRAC in case of a rate > 20 and no sensible results are obtained at all.
- **For the '1 compressed image' scenario much higher HD scores are obtained**, except for PRVQ showing similar scores to the 2 compressed images case and thus being clearly the best algorithm in this scenario.
- **Compression up to a rate of 16 even improves matching scores of uncompressed images**: this claim stated by Rakshit and Monro[c] can be supported at least for the 2 compressed images case.



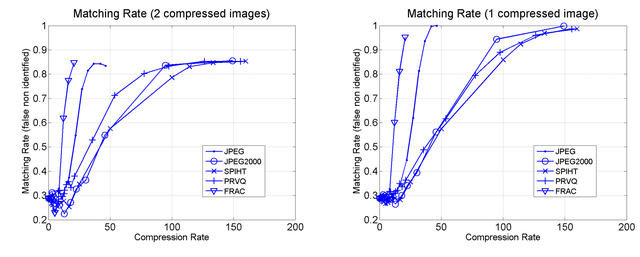
(a) 2 compressed images (b) 1 compressed image

Fig. 4 Comparison of the HD for iris images for legitimate users.

[c] S. Rakshit and D.M. Monro, "Effects of Sampling and Compression on Human Iris Verification," in *Proceedings of the IEEE International Conference on Acustics, Speech, and Signal Processing ICASSP 2006, IEEE Signal Processing Society*, pp. II-337–II-340, Jul. 2007.

Comparing compression impact on FMR/FNMR

For biometric system assessment, False Match Rate (FMR) and False Non Match Rate (FNMR) are frequently employed. FMR is found to stay at 0% for all compression algorithms in the 1 compressed image case. For 2 compressed images, we found one false positive match at compression rate 130 with SPIHT, however such high compression rates are not likely to be employed in realistic scenarios.
Fig. 5 illustrates FNMR as a function of compression rate for all tested algorithms. Here, PRVQ is worse compared to JPEG2000 and SPIHT in the 2 compressed images case, which suggests the existence of more statistical outliers as for the other techniques which exhibit a similar ranking behavior as when comparing average HD values.



(a) 2 compressed images (b) 1 compressed image

Fig. 5 FNMR with decision threshold at 0.32.

Once again we would like to point out the performance difference between JPEG and JPEG2000: whereas JPEG reaches a FNMR of 50% at a compression rate of 20, JPEG2000 attains the same value at a compression rate of 40. However, for lower bit-rates (and more realistic FNMR values), the difference is not that pronounced but still significant.

Conclusion

JPEG2000, SPIHT, and PRVQ have been shown to be almost equally well suited for iris image compression. JPEG performance is found to be significantly inferior to those techniques. Finally, fractal compression can be said to be non-suited at all for this application, due to failing iris detection for compression rates greater than 20. Compression is found to increase FNMR but does not impact FMR, thus affecting "only" user convenience. Matching with two compressed images delivers better scores and lower FNMR as compared to the case of compressing only one image. Differences among compression algorithms are relatively small in a high quality environment with compression rates smaller than 10.