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Discussion

Iris recognition—the need to recognise the iris as a dynamic biological system: Response to Daugman and Downing

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Daugman and Downing [1] have made a number of assertions with respect to our recently published paper [2] which we will address in turn:

(a) The suggestion is made that there was head tilt or cyclotorsion that would have altered the images and influenced the temporal comparisons. We are well aware that such head and eye movements can occur and therefore ensured that they were avoided by using a clinical biomicroscope for image capture. Such instruments are used routinely in ophthalmic clinics and are relied upon by surgeons to keep eye and head position still. Head tilt is prevented by use of a head rest and chin bar and cyclotorsion was avoided by controlling primary gaze position with a fixed target during image capture. This was further monitored by carefully aligning Purkinje images (reflections from the ocular surfaces) in successive photographs to ensure that the eyeball gaze position was steady from image to image. Since the cornea is a toric lens, any cyclotorsion would have resulted in a change of meridian orientation and a shift or change in the shape of the Purkinje image. This did not occur. Additionally we implemented cyclic rotation (as proposed in Masek's original implementation) as a mechanism for registration in the matching process in order to account for any possible head tilt differences between images.

(b) The assertion that our segmentation was '*unstable*' is incorrect. Only images in which iris segmentation was successful were used in this study. Great care was taken to locate the pupil and limbal boundaries (as stated in the paper). As segmentation was accurate, there were no coordinate shifts. The purpose of this study was to analyse feature extraction techniques and their robustness over time and so only accurately segmented iris images could be used.

(c) We want to clarify some queries about texture change. We have made no claim to have found such marked changes in texture that would be evident in a photograph. When we discuss changes we refer to changes at the level of the binary code. The comparisons we make are therefore comparisons of bit strings that encode the image features and not of the image itself. They are not evident in a photograph for if they were, there would be no need for algorithms in the comparison of images. We would agree with the authors of [3] that '*if the iris aging affect is real, it is based on subtle differences*'. It is surprising that Daugman and Downing ask for photographic evidence when they should be aware that photographic images could not possibly show such subtle binary level changes. Recent work, [4,5], also shows the effect of iris biometric template ageing on iris images acquired with near infra-red sensors, with the effect detectable in the match scores rather than by human visual evaluation. The authors assert that '*there is no published documentation of changes in iris texture*'. This does not mean that changes with time do not occur but rather that there have not been any sufficiently long-term studies using such accurate image capture methods as the biomicroscope. Daugman and Downing cite Aslam

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et al. [6] as evidence of no changes in texture detected in diseased states. That study used very small groups of subjects for each disease condition and therefore could not make definitive conclusions.

(d) In spite of the continual critique of iris texture being immutable, Daugman and Downing acknowledge that various features, such as '*freckles, pigment blotches and colour*' can change with time. These are features associated with texture as these are generally characteristics of pigmentation: clumps of pigment, uneven distribution, variations in density. They are important features for iris recognition because, just like freckles on the skin, they vary between individuals in shape, density, location. Such features are described by Daugman and Downing as '*irrelevant*' for current iris recognition systems that use infrared illumination. However, they are not irrelevant if one wants to investigate the iris in more depth using an imaging system that does not mask the existence of these pigmented features. Indeed, our study presents a new way of considering iris imaging and recognition by utilising sources that identify more features in images of greater magnification and therefore with greater detail.

(e) Daugman and Downing stated that '*mere algorithm implementation failures are responsible*' for the findings that we report. Yet no evidence for this assertion is provided. Such a bold statement appears to be based purely on assuming that the iris does not alter with time. The iris is a biological tissue subject to physiological processes and under control of the autonomic nervous system. It cannot but alter with age and hence show changes with time. The detection of changes depends to a large extent on the method used and most importantly on the details that can be captured within the images.

(f) It is further stated that '*such scores commonly arise simply from algorithm weaknesses such as unstable coordinate alignments.*' Our paper describes the use of Masek's matching algorithm which implements Hamming distance to measure dissimilarity between two iris images [7], as in Daugman's original matching algorithm [8–10]. Masek also implemented a further improvement (detailed in his code [7]) that involved shifting one of the iris templates in each direction and computing a Hamming distance at each shift. We also implemented cyclic rotation (as proposed in Masek's original implementation) using shifting of ± 4 rather than ± 5 as used by Masek; in experimentation other shifting values were tried but did not produce better results. The minimum of the computed Hamming distances is used as the match score, thus ensuring that even if coordinate alignments were not precise between two images, such shifting corrects this and obtains the lowest match score. We feel that use of cyclic rotation combined with the measures taken at image acquisition to prevent head tilt and cyclotorsion, described in part (a), are sufficient to avoid '*unstable coordinate alignments*'.

(g) It is a little surprising that Daugman and Downing state that circular models for boundary contours '*can generate rivalrous alternate solutions*'. To the best of our knowledge this has never been mentioned before and the seminal iris localisation technique developed by Daugman modelled the iris using circular boundaries [8]. Indeed, almost all studies undertaken since have followed such a methodology [11–15] and each of these studies, in addition to evaluation by Daugman [8–10], has cited excellent recognition rates when using circular boundary models. It was only in 2007 that Daugman [16] introduced the method of localisation using active contour models. Even at this point he did not describe any serious problems arising from the use of circular iris boundary modelling in his earlier work.

(h) The final paragraph about iridology we find to be unreasonable and we are surprised that this has been included. Our paper does not mention nor imply any support for this practice nor does '*a belief in constant changes in iris pattern pervade*' our carefully researched work which is based on sound scientific principles.

References

[1] J. Daugman, C. Downing, No change over time is shown in Rankin et al., "Iris recognition failure over time: the effects of texture", Pattern Recognition (2012).

[2] D.M. Rankin, B.W. Scotney, P.J. Morrow, B.K. Pierscionek, Iris recognition failure over time: the effects of texture, Pattern Recognition 45 (2012) 145–150.

[3] S.E. Baker, K.W. Bowyer, P.J. Flynn, Empirical evidence for correct iris match score degradation with increased time-lapse between gallery and probe matches, Lecture Notes in Computer Science 5558 (2009) 1170–1179.

[4] S.P. Fenker, K. Bowyer, Experimental evidence of a template aging effect in iris biometrics, IEEE Workshop on Applications of Computer Vision (WACV), 2011, pp. 232–239.

[5] N. Sazonova, F. Hua, X. Liu, J. Remus, A. Ross, L. Hornak, S. Schuckers, A study on quality-adjusted impact of time lapse on iris recognition, Proceedings of SPIE 8371 (2012) 83711W-8-83711W-9W.

[6] T.M. Aslam, S.Z. Tan, B. Dhillon, Iris recognition in the presence of ocular disease, Journal of the Royal Society Interface 6 (34) (2009) 489–493.

[7] L. Masek, Recognition of Human Iris Patterns for Biometric Identification, The University of Western Australia, 2003, [Online] Available at: 〈http://www.csse.uwa.edu.au/~pk/studentprojects/libor/LiborMasekThesis.pdf〉.

[8] J. Daugman, High confidence visual recognition of persons by a test of statistical independence, IEEE Transactions on Pattern Analysis and Machine Intelligence 15 (1993) 1148–1161.

[9] J. Daugman, Statistical richness of visual phase information: update on recognizing persons by iris patterns, International Journal of Computer Vision 45 (1) (2001) 25–38.

[10] J. Daugman, How iris recognition works, IEEE Transactions on Circuits and Systems for Video Technology 14 (1) (2004) 21–30.

[11] D.M. Monro, S. Rakshit, D. Zhang, DCT-based iris recognition, IEEE Transactions on Pattern Analysis and Machine Intelligence 29 (2007) 568–595.

[12] R. Wildes, Iris recognition: an emerging biometric technology, Proceedings of the IEEE 85 (1997) 1348–1363.

[13] W.W. Boles, B. Boashash, A human identification technique using images of the iris and wavelet transform, IEEE Transactions on Signal Processing 46 (1998) 1185–1188.

[14] L. Ma, T. Tan, Y. Wang, D. Zhang, Personal identification based on iris texture analysis, IEEE Transactions on Pattern Analysis and Machine Intelligence 25 (2003) 1519–1533.

[15] M. Nabti, L. Ghouti, A. Bouridane, An effective and fast iris recognition system based on a combined multiscale feature extraction technique, Pattern Recognition 41 (2008) 868–879.

[16] J. Daugman, New methods in iris recognition, IEEE Transactions on Systems, Man, and Cybernetics Part B Cybernetics 37 (2007) 1167–1175.