GA-Based Iris/Sclera Boundary Detection for Biometric Iris Identification

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Abstract. Iris identification (IRI) constitutes an increasingly accepted methodology of biometrics. IRI is based on the successful encoding and matching of distinctive iris features (folds, freckles etc.), which - in turn - presupposes that iris segmentation has been accurately performed. In contrast to the inner (iris/pupil) iris boundary, which – owing to the high contrast between the adjacent areas - is relatively easy to localize, detection of the outer (iris/sclera) iris boundary is more challenging since the low contrast between the separated areas often results in fragmented, ambiguous and spurious edges. A novel approach to iris boundary detection is presented here, featuring a genetic algorithm (GA) for outer iris boundary detection.

1 Introduction

Iris identification (IRI) constitutes an increasingly accepted biometrics methodology of information technology, especially as it combines a number of advantages such as non-invasiveness\(^1\), ease/speed of capture, high discriminative power, constancy over a variety of factors (aging, mood, fatigue etc.), small false acceptance and rejection rates etc. IRI is based on the successful encoding and matching of distinctive iris features (folds, freckles etc.), which - in turn - presupposes that iris segmentation has been accurately performed. In this piece of research, the iris segmentation stage preceding iris encoding and matching from near-infrared filtered images is described. Iris segmentation comprises the extraction of the iris/pupil (inner) and the iris/sclera (outer) boundaries, both of which are approximated by (not necessarily concentric) circles.

Contrary to a limited number of reported approaches [1-2], where outer iris boundary detection precedes that of the inner iris boundary, in this piece of research

\(^1\) The equipment used for capturing the subject’s iris does not come into direct contact with the subject (e.g. compared with fingerprint biometrics); furthermore the capture conditions are such as not to make the subject feel uncomfortable, uneasy or fatigued (e.g. compared with retinal scan biometrics).
(and similar to [3-10]) inner iris boundary detection is performed first and the extracted inner boundary circle (IBC) characteristics are used for guiding outer boundary circle (OBC) localization. Such a sequence of circle finding has been preferred since - owing to the high contrast between the adjacent areas – the IBC is relatively easy to localize; on the contrary (and due to the lower contrast between iris and sclera), OBC detection is significantly more challenging and often results in fragmented, ambiguous and spurious edges.

IBC and OBC extraction have been implemented so as to simultaneously accommodate the four well-known benchmark iris databases (namely CASIA v1.0 and CASIA v2.0 [11], MMU [12] and the Bath University Sample Database [13]), thus endowing the proposed approach with portability and universality. The images of the aforementioned databases are gray-scale images showing the iris of human subjects together with most (or all) of the eye, eyelids, eyelashes and some skin. These images have been captured employing near-infrared filters, an especially useful tool for accurately capturing the iris features of highly pigmented irises.

2 Inner Iris Boundary Detection

Integro-differential operators (IDO), [14], the Hough transform (HT) [15], Canny edge detection (CED) [16] and intensity thresholding (IT) constitute the main tools employed for determining the iris/pupil boundary (e.g. purely IT-based methodologies [1,7-8], IT followed by edge detection and HT [3-4] or by IDO and HT [6], CED combined with HT and IT [5,9]). Approximation of the inner iris boundary by a circle is the norm [1-10,14]; the more computationally complex approach of ellipse approximation has been implemented in [17], without – however – a significant improvement in accuracy.

Owing to the significant contrast between iris and pupil as well as the high concentration of (almost) black pixels in the latter, an IBC is quite straightforward to construct. A purely geometric approach has been implemented here which comprises two stages: image thresholding and extraction of the IBC characteristics (centre and radius). For the following, only the central 64% part of the image has been considered (window extending above, below, to the left and to the right of the central pixel by 40% relative to the image height and length).

2.1 Image Thresholding

A threshold $\theta$ is sought such that, after window thresholding, a black/white image pixel (with intensity lower/higher than $\theta$) most probably belongs/does not belong to the pupil. Determining such a $\theta$ is far from straightforward for IRI: on the one hand, the conditions of iris image capture (e.g. from different databases) result in different image intensity characteristics; on the other hand, even under the same conditions (e.g. within the same database), a significant variability in intensity is observed,

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2 This has been selected due to its ease and speed of implementation.

3 Successful IRI cannot be guaranteed when the pupil lies outside this part of the image; additionally, the outer part of the image offers no pupil pixel intensity information.