End-to-end Off-angle Iris Recognition Using CNN Based Iris Segmentation

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Outlines

Introduction and problem statement

Introduction

- Accurate segmentation and parameterization of the iris in the off-angle eye images still reminds a challenge in iris recognition.
- Showing superior performance, convolutional neural networks are increasing being used for iris segmentation/recognition [1] [2].

Problem statement

- There is no comprehensive recognition framework dedicated for off-angle iris recognition using such modules.
- Having such knowledge available, we can figure out the proper segmentation and recognition strategy when using CNNs in such applications.
- It might turn out that CNN training has to be done specifically for a certain gaze angle (eye-gaze estimation algorithms required).
- Alternatively, it may be of advantage to improve the generalization capability of the networks, and thus eliminate the need for any further processing stages.

Methods

- Introduce an iris parameterization (correction) algorihtem to re-project back the off-angle images to frontal view.
- Use an improvement scheme to compensate for some segmentation degradations caused by the off-angle distortions.
- Investigate the effect of different gaze-angles on the CNN based off-angle iris segmentations, and their recognition performance, under "improved-homogeneous" approach.
- Determine if the generalization capability of the network can be improved by training it on iris images of different gaze-angles, under "improved-heterogeneous" approach.
- Formulate "corrected-heterogeneous" and "corrected-homogeneous" approaches to clarify if correcting the iris images after the segmentation, can compensate for off-angle distortions.

Experimental framework

- **Database:** A database containing 4400 left eye iris images belonging to 40 subjects (captured from -50°(N50) to +50°(P50), with a 10° step) is used.
- **Segmentation evaluation and measures:** Nice1 (NICE protocol)[1]
- **Recognition evaluation and measures:** EER.
- **Fully convolutional neural network (FCN):** "RefineNet" [3].
- **Recognition pipeline:**

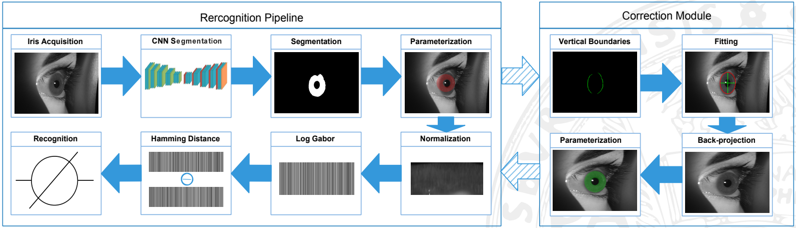


Figure. Recognition pipeline and the correction module

[1] http://nice1.di.ubi.pt/

Segmentation improvement

Segmentation improvement

- It was already understood that the network tends to produce some false-positive detections along the segmentation output masks borders [4].
- So, we defined a marginal area (A) along each border of the segmentation output masks (with a width (in pixel) equal to $1/5$ of the length of the same border), and then performed an opening operation with a big (disk-shape) structuring element (B):

$$A \circ B = (A \ominus B) \oplus B. \tag{1}$$

.

- We further performed another opening operation on the whole segmentation outputs using a small (disk-shape) structuring element.

Figure. Sample iris segmentation before and after applying the improvement

Off-angle iris parameterization

- The available algorithms used for parameterization are limited to circular Hough transform due to the tendency of such models to overly oblong or obround, because of occlusion of the iris by eyelids or eyelashes.
- We propose to search only for the vertical edges in the segmentation outputs. The resulting edge points secure the proper fitting of an ellipse to the actual iris region.
- Assuming that our ellipse is in the following parametric form:

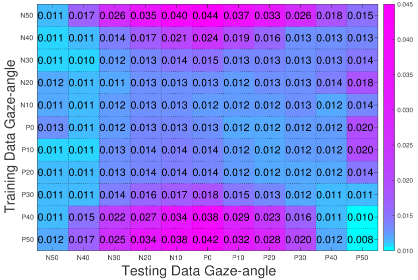
$$x = x_0 + Q \times \begin{bmatrix} a \times cos(\theta) \\ b \times sin(\theta) \end{bmatrix}. \quad (2)$$

- We infer the affine transformation matrix we need to re-project the parameterized ellipse back to frontal view:

$$x = \left[Q \begin{bmatrix} 1 & 0 \\ 0 & a/b \end{bmatrix} Q' \right] x + \left[\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - Q \begin{bmatrix} 1 & 0 \\ 0 & a/b \end{bmatrix} Q' \right] x_0. \quad (3)$$

Improved-homogeneous approach

- We trained the network on iris images with identical gaze-angle (200 images per gaze-angle as in our training data).
- Then we conducted segmentation, and after improving the segmentations, the recognition on the whole testing data, differentiating and grouping results into the different gaze-angles available.



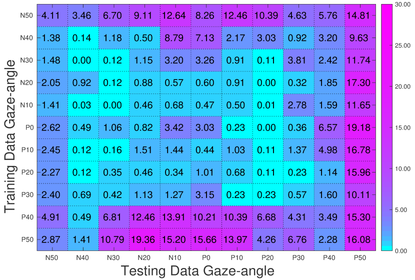
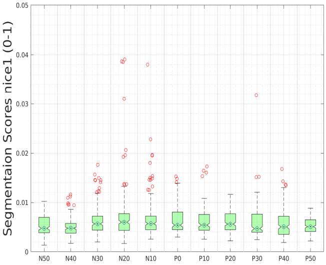


Figure. Segmentation and recognition performance under the improved-homogeneous approach

Does heterogeneous training helps

Improved-heterogeneous

- We trained the networks with all (200 samples per gaze-angle), images in our training data, and then tested the networks on all images in the testing data.
- Differentiated and grouped the results into the different gaze-angles available.



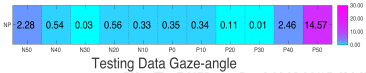
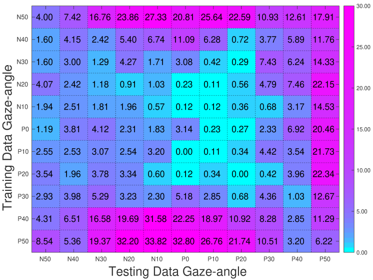


Figure. Segmentation and recognition performance under the improved-heterogeneous approach

Corrected-homogeneous and heterogeneous

- We re-projected the improved segmentation outputs obtained in the previous step along with their corresponding iris images back to frontal view.
- The corrected data then was fed into the recognition pipeline to evaluate the recognition performance.



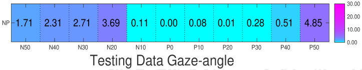


Figure. Recognition performance under the corrected-homogeneous and corrected-heterogeneous approache

Analysis and conclusion

- The improvement technique proved to compensate for some off-angle related segmentation degradations, enhancing the segmentation results beyond those obtained in [4], and the subsequent recognitions.
- The experimental results of the improved-homogeneous approach affirmed the direct relation of the network performance to the similarity of gaze-angles of the training and testing images.
- We also found that the network performance gradually improves as the gaze-angle of the training and testing data converges in terms of angle but diverges in terms of direction.
- This confirmed the capability of the network to detect the symmetric iris contents in the iris images captured from the same angle but in the opposite direction.

Analysis and conclusion

- The experimental results of the gaze-angle correction approaches showed that the interpolation applied during the correction procedure and the possible imperfections of the correction algorithm, can influence the distinction of the iris images and thus undermine their subsequent recognition performance.
- Unless applying it to iris images with closed-to-frontal gaze-angles (*i.e.* up to 20), and performing perfect (error free) correction, the angle correction based approaches are not expected to deliver promising recognition results (specially on the +20 off-angle images), when applied on the CNN based off-angle segmentations.
- The experimental results of the heterogeneous approaches, in practice, delivered very positive result, as it enabled us to refrain from the angle-specific training strategy, and even from the need for correcting the images' gaze-angles before being able to deploy the recognition systems.

Thank you, Remarks?

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