The NICE.I: Noisy Iris Challenge Evaluation - Part I

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Abstract— **This paper gives an overview of the NICE.I : Noisy Iris Challenge Evaluation - Part I contest. This contest differs from others in two fundamental points. First, instead of the complete iris recognition process, it exclusively evaluates the iris segmentation and noise detection stages, allowing the independent evaluation of one of the main recognition error sources. Second, it operates on highly noisy images that were captured to simulate less constrained imaging environments and constitute the second version of the UBIRIS database (UBIRIS.v2). Further details can be seen at the contest web site (http://nice1.di.ubi.pt).**

I. Overview

The iris is often accepted as one of the most accurate traits and has been successfully applied in such distinct domains as airport check-in [1] or refugee control [2]. However, for the sake of accuracy, current iris recognition systems require that subjects stand close (less than two meters) to the imaging device and look for a period of about three seconds until the data is captured. Some iris biometric evaluations have been conducted using images that fit these constraints (e.g., the Iris Challenge Evaluation, ICE [3]).

However, the highly constrained imaging conditions and the cooperative behaviour required of subjects clearly restrict the range of domains where iris recognition can be applied. It is probable that image capturing on less constrained conditions (either at-a-distance, on-the-move, with minor cooperation or within dynamic imaging environments) lead to the appearance of extremely heterogeneous images, with several other types of data in the captured iris regions (e.g., iris obstructions due to eyelids or eyelashes, reflections, off-angle or motion blurred images). Figure 1 illustrates some of the noise factors that appear in images acquired under less constrained imaging conditions.

Fundamentally, the Noisy Iris Challenge Evaluation - Part I [4] differs from the above mentioned contests in two points:

- It operates on noisy iris images, similar to those contained by the UBIRIS [5] database. These images constitute the second version of the UBIRIS database (UBIRIS.v2). When compared to its predecessor, this database has more images and with new and more realistic noise factors.
- It exclusively evaluates the iris segmentation and noise detection stages, allowing the independent evaluation of these tasks that are known to be primary recognition error sources.

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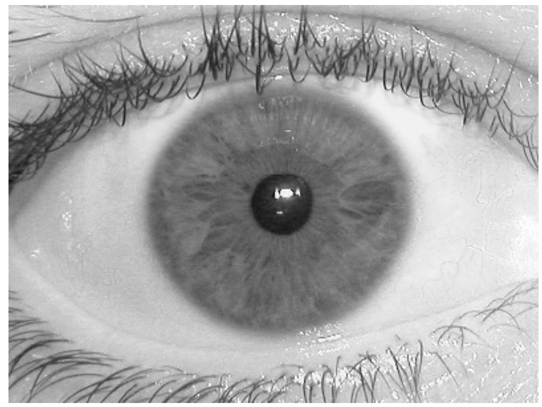
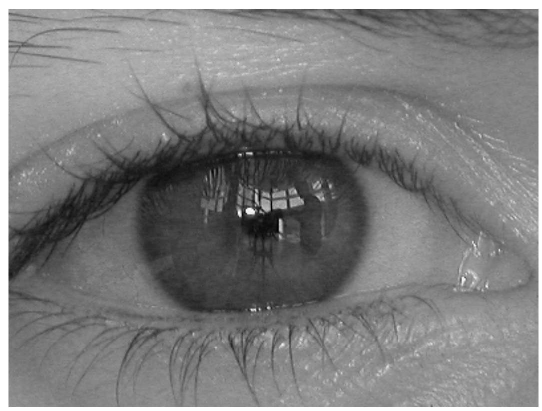


(a) Iris image with good quality.



(b) Noisy iris image.

Fig. 1. Comparison between a good quality image and a noise-corrupted one. Figure 1a was captured under high constrained imaging conditions and is completely noise-free. Oppositely, figure 1b incorporates several types of noise, resultant from less constrained imaging conditions. It can be observed several iris obstructions - due to eyelids and eyelashes - and large regions of the iris corrupted by reflections.

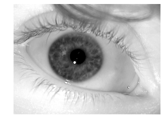
A. Noise Factors

In this section we identify and describe the noise factors that appear under less constrained imaging processes, either at-a-distance, on-the-move, with minimal subjects cooperation and within heterogeneous lighting environments. We base this description on observations we have made during our imaging experiments and while studying the available image databases (CASIA [6] (three distinct versions), MMU [7], BATH [8], UPOL [9], ICE [3], WVU [10] and UBIRIS [5]).

1) Poor focused iris images. Due to the moving elements that interact in the image capturing and to the limited depth-of-field of the imaging device, the image focus is one of the main concerns. Often, small deviations (centimeters) in the imaging distance lead to severe focus problems, which almost invariably increment the false rejection rates.
2) Off-angle iris images. Due to rotation of the subjects head and eyes, iris images are often captured without proper alignment. These off-angle images have elliptical shape for the region corresponding to the iris and demand the use of projection techniques, in order to deal with the iris data as if it was not off-angle.
3) Rotated iris images. It is possible to capture the iris data rotated, when the subject's body / head is not in the vertical (natural) position.
4) Motion blurred iris images. The iris image can be blurred by motion. Eyelids movement significantly contributes to this type of noise.
5) Iris obstructions due to eyelashes. Eyelashes can obstruct portions of the iris in two distinct forms as they appear isolated or grouped. If an eyelash is isolated it appears as a very thin and darker line in the iris region. The existence of multiple eyelashes in the iris regions generates a uniform darker region.
6) Iris obstructions due to eyelids. Eyelid movement can obstruct relevant portions of the iris, especially in its vertical extremes. Commonly, this noise factor affects the largest portion of the iris.
7) Iris obstructions due to glasses. Glasses can obstruct some portion of the iris data, especially if the image capturing is not frontal to the subject.
8) Iris obstructions due to contact lenses. Contact lenses, especially those with high optical power, are a relevant obstacle to recognition, as they obstruct and non-linearly deform portions of the iris texture.
9) Iris with specular reflections. Usually, these areas have almost maximal intensity values and appear as small spots that obstruct the iris texture.
10) Iris with diffuse reflections. This type of reflections corresponds to reflected information from the environment where the user is located or is looking at. These reflections can obstruct large regions, or even the majority, of the iris. Commonly, they have lower intensity values than the specular reflections and can correspond to a wide range of objects that the user is surrounded by.
11) Partial captured iris. The image capturing at-a-distance and on-the-move propitiates that resultant images contain exclusively portions of the iris.
12) Out-of-iris images. This is an extreme noisy factor and, obviously, denies any attempt of biometric recognition. However, it should be considered, to avoid false acceptances motivated by the analysis of non-iris areas.

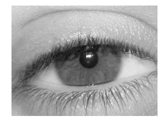
(a) Poor focused iris image.

(b) Off-angle iris image.

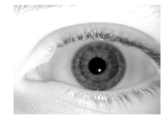


(c) Rotated iris image

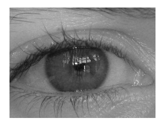
(d) Motion blurred iris image.



(e) Iris with eyelid and eyelash obstructions.



(f) Eye with contact lenses.



(g) Iris with large reflection areas.

(h) Partial captured iris image.

(i) Out-of-iris image.

Fig. 2. Examples of noisy iris images. These images contain the majority of the above described noise factors, that result from less constrained image capturing conditions.

B. UBIRIS database

The UBIRIS [5] database was developed within the SOCIA Lab. (Soft Computing and Image Analysis Group) at the University of Beira Interior (Portugal) and released in September, 2004. Its most fundamental characteristic is the high levels of noise that images contain, to simulate less constrained image capturing conditions. It was downloaded by over 500 users (individuals and academic, research and commercial institutions) from over 70 different countries of the world (figure 3). Moreover, we have knowledge of several MSc. and BEng. final projects whose experiments were exclusively made with $UBIRIS$ images.

Based on the strong acceptance of the first version of the UBIRIS database and in the observed lack of more realistic noise factors, we decided to build a second version of the UBIRIS database: UBIRIS.v2. Our goal was to more realistically simulate less constrained image capturing conditions, either at-a-distance, on-the-move and with minimal subjects cooperation. When compared to its predecessor, this database contains more images and with new noise factors, namely all that are described in section I-A.

II. Protocol

1) **Overview.** In order to participate in the NICE.I contest, an application executable and a registration form should be submitted. The executable should receive the path of a close-up iris image (through command-line arguments) and perform its segmentation, distinguishing between the regions of the iris unobstructed by any type of noise and all the remaining ones.

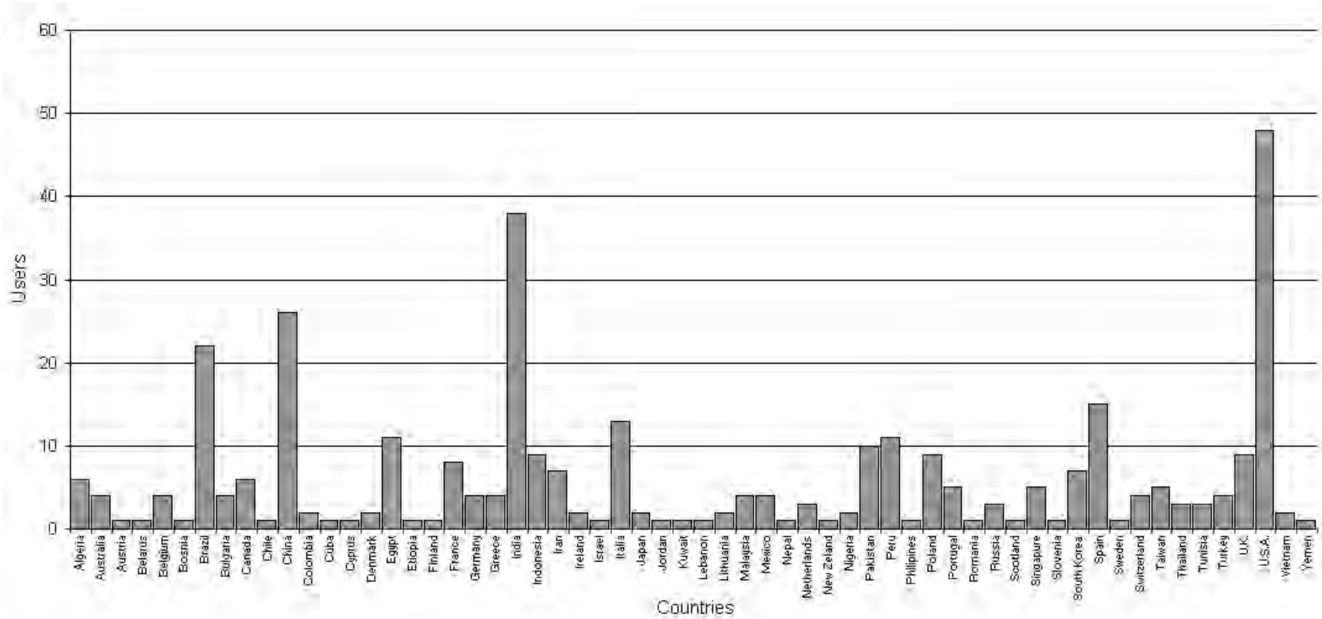
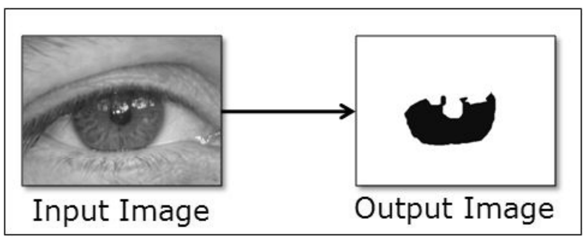
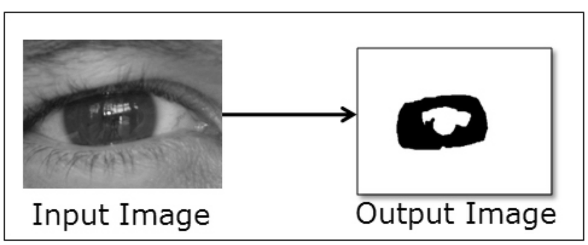


Fig. 3. Histogram of the countries from where the users of the UBIRIS database were registered.



(a) Example of the NICE.I task.



(b) Example of the NICE.I task.

Fig. 4. Examples of the NICE.I fundamental task. Receiving a close up noisy iris image, it should be produced a correspondent binary image that distinguishes between the noise-free regions of the iris and all the remaining ones.

a) The application executable can be written in any programming language and must run in stand alone mode, in one of the operating systems: "Microsoft Windows XP, with Service Pack 2" or "Fedora Core 6".
b) An overview of the task demanded to the NICE.I participants is given in figure 4. Receiving the pathname of a close-up and noisy iris image (in ".tiff" format), the executable should output a correspondent binary image (with the same name, size and in ".bmp" format), where the pixels that correspond to the noise-free iris regions appear as black (intensity=0) and all the remaining ones appear as white (intensity=255).

2) **Registration**. Each NICE.I participant receives a username that will be the name of the submitted executable.
   a) Each participant is allowed to submit one single algorithm and executable.
   b) NICE.I participation agreement. The application form must be signed by the corresponding participant and sent to the contest email address.

3) **Evaluation**. The evaluation of the NICE.I contest will be automatically made through a Java framework built and a set of manually classified images of the UBIRIS.v2 database.
   a) The evaluation framework will be available to all the NICE.I participants, in order to facilitate the training and tuning of the segmentation algorithms.
   b) It will be given a data set of noisy iris images (portion of the UBIRIS.v2 database) with close characteristics to the images used in the evaluation stage. To enable the automatic evaluation, the manually classified images will be given too.
   c) The output images should have the same name of the respective input images and ".bmp" format. These will be compared to the manually classified images to compute the error rates.

III. EVALUATION

Let Alg denote the application executable that performs the segmentation of the noise-free iris regions. Let $I = \{I_1, \ldots, I_n\}$ be the input data set of close-up iris images and $O = \{O_1, \ldots, O_n\}$ the correspondent outputs, such that $Alg(I_i) = O_i$.

Let $C = \{C_1, \ldots, C_n\}$ be the manually classified binary iris images given by the NICE.I Organizing Committee. It must be assumed that each C_i contains the perfect iris segmentation and noise detection output for the corresponding input image I_i. All the images of I, O and C have the same dimensions: c columns and r rows.

The classification error rate on the I_i image (E_i) is given by the proportion of disagreeing pixels (through the logical exclusive-or operator) over all the image:

$$E_i = \frac{1}{c \times r} \sum_{c'} \sum_{r'} O(c', r') \otimes C(c', r') \quad (1)$$

where $O(c', r')$ and $C(c', r')$ are, respectively, pixels of the output and class images.

The classification error rate (E) of the Alg participation is given by the average errors on the input images:

$$E = \frac{1}{n} \sum_i E_i \quad (2)$$

The value of (E) (closed in the $[0, \ 1]$ interval) is the measure of evaluation and classification of the NICE.I contest. Thus, "1" and "0" are respectively the worst and optimal error values.

IV. PUBLICATION

There are two alternatives to publish the approaches used in the NICE.I contest. They are optional, which means that participants will have the option of not to publish their method.

1) The participants that achieve the best 10 results (lowest error values (2)) are invited to submit a paper that, upon revision by the NICE.I Organizing Committee, will be published in a special issue of the *Elsevier Image and Vision Computing Journal* [11]. These papers should follow the instructions described in the Journal's web site (maximum of 16 pages).
2) The remaining participants are invited to submit a paper to be electronically published in the *Proceedings of the Noisy Iris Challenge Evaluation - Part I* (with ISBN). These papers should be formatted into double column, according to the IEEE proceedings format (maximum of 4 pages) and will be available in the contest web site.

V. IMPORTANT DATES

- July 1st, 2007: Start of the NICE.I application forms reception period.
- November 1st, 2007: Start of the NICE.I contest (delivery of the training data set and contest framework).
- April 1st, 2008: Deadline for the submission of application executables.
- May 1st, 2008: NICE.I classification. The results are given in the contest web site.
- July 31th, 2008: Deadline for paper submission.
- Date to be confirmed. Deadline for major revisions.
- Date to be confirmed. Deadline for minor revisions.
- Date to be confirmed. Deadline for camera-ready papers.
- Date to be confirmed. Publication of the *Elsevier Image and Vision Computing Journal* special issue. Electronic publication of the NICE.I proceedings.

VI. ACKNOWLEDGMENTS

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