An Evaluation Benchmark for Preprocessing and Recognition of Spatially Variant Blurred Iris Images

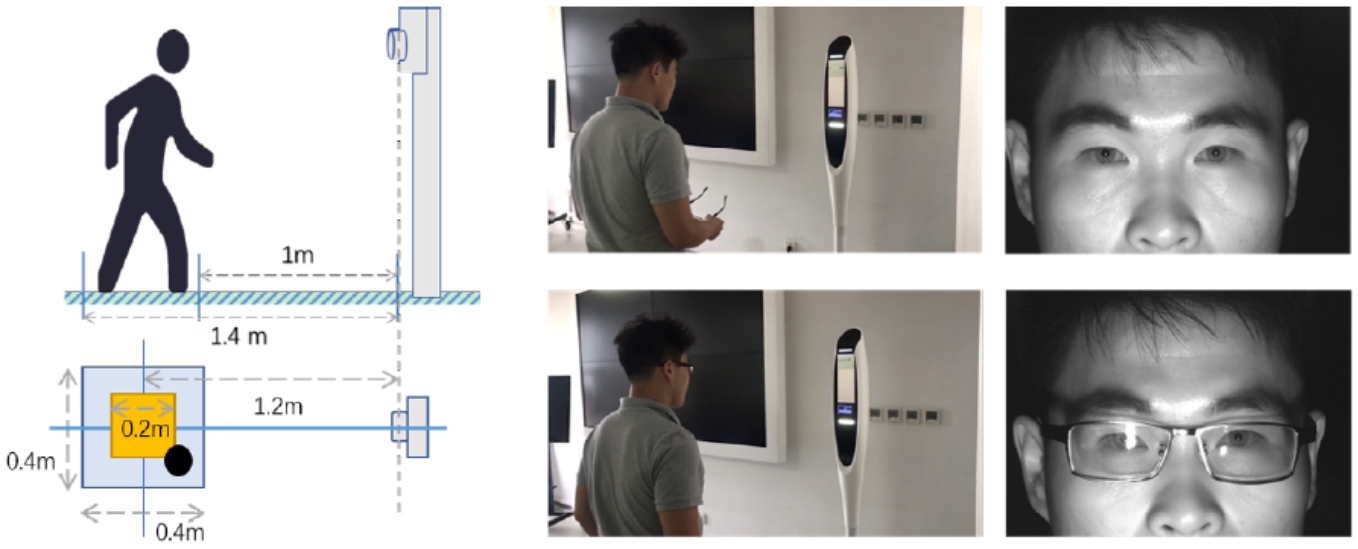
1. Introduction

A key problem of iris recognition at a distance (IAAD) is that a large portion of captured iris images is spatially variant blurred because of narrow depth of field (DoF), noncooperative user movement, incongruous exposure time and so on. Current iris recognition systems usually filter out these low-quality images using strict criteria of image quality evaluation (IQA). However, this strategy inevitably leads to a waste of device capacity and low throughput. In addition, IAAD under covert conditions does not work without the cooperation of users. Therefore, a better and practical solution is to utilize blurry iris images for personal identification. However, there does not exist a publicly available database containing a large number of defocused or motion-blurred near-infrared (NIR) iris images with labeled identities and annotated segmentation masks. We announce the availability of a long-range captured dataset containing 3,756 iris images of varying blur levels from 98 subjects. An evaluation benchmark is built upon the dataset for a comparative study on preprocessing and recognition of spatially variant blurred NIR iris images.

2. Descriptions and Statistics of the Database

Image collection

The schematic and setup of blur-varying iris image collection of this database at a distance are shown as following.

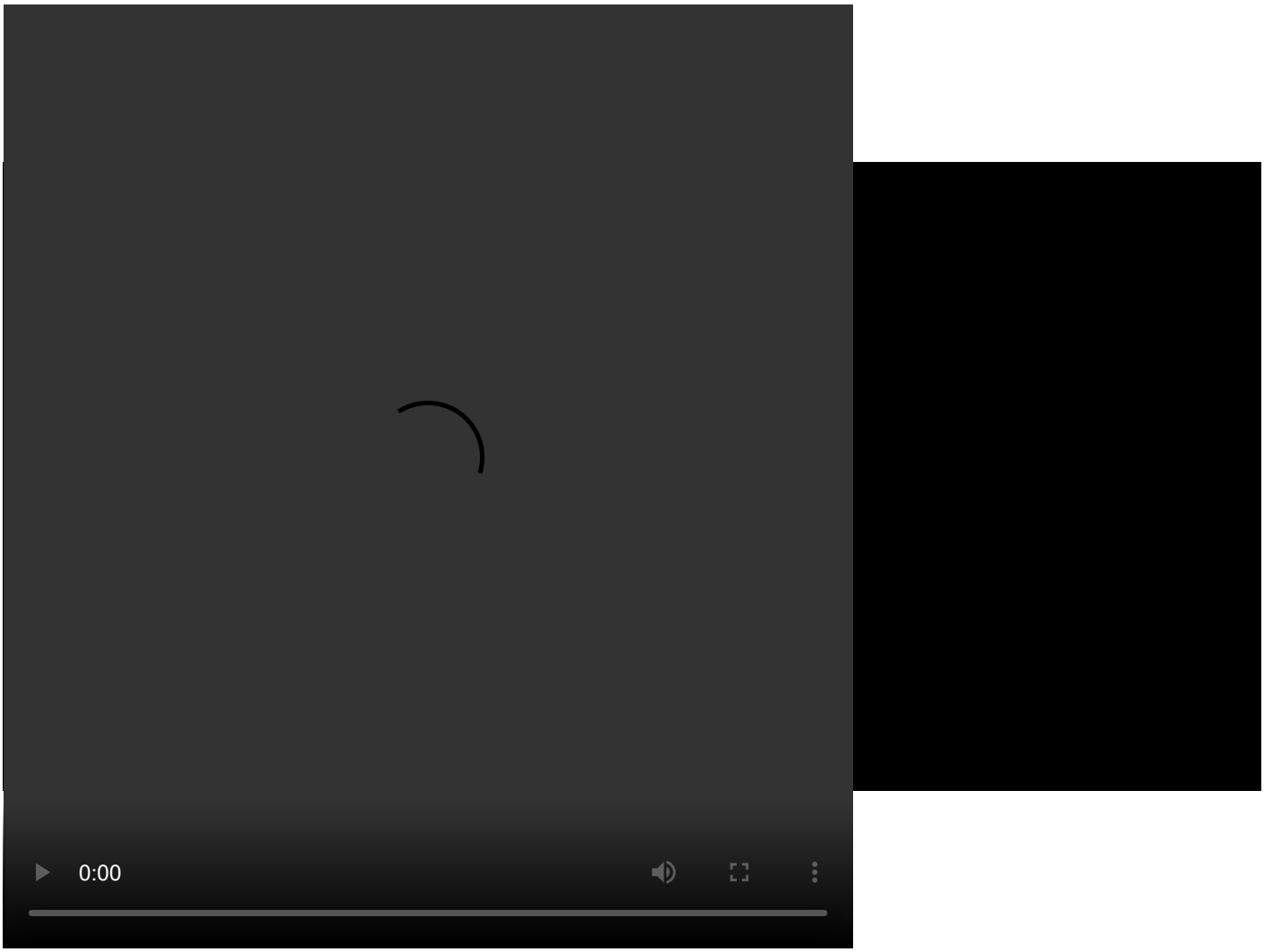


(a) (b) (c)

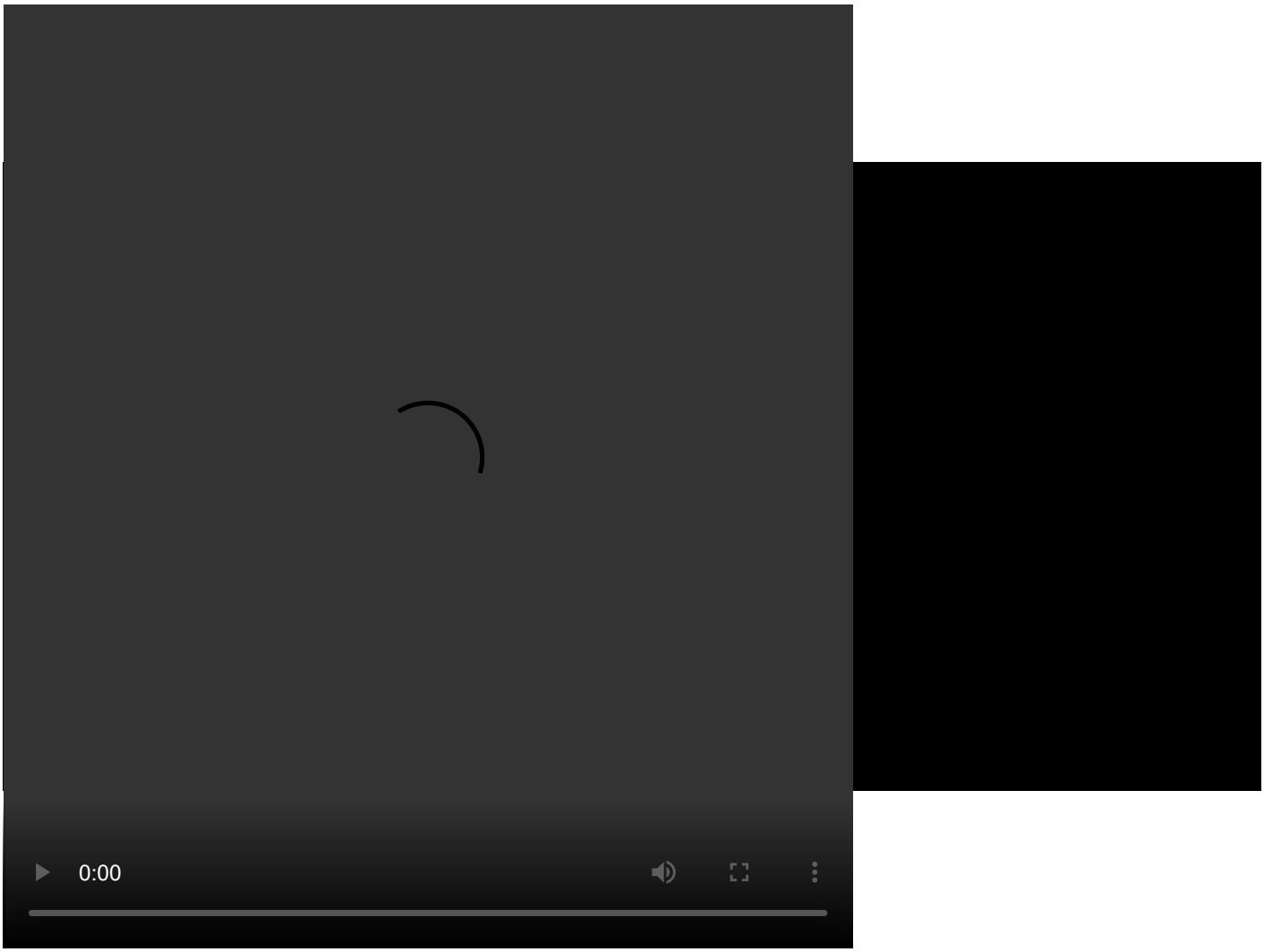
The next generation of CASIA-LR-Cam bundled with NIR illumination at a wavelength of 830 nm was employed as the capturing device. Its standoff distance is approximately 1.2 meters with a DoF of over 20 centimeters. The field of view (FoV) is approximately 20 degrees. The device was placed in an indoor environment under no extra lighting sources. During the process of image collection, the subjects were obliged to move freely in the restricted square area 1.0~1.4 meters away from the device. Specifically, they could casually step forward and backward, left and right.

While moving inside the restricted area, the subjects were guided by the signal on the screen to look directly into the imaging device for approximately 30 seconds in a single session. Two separate sessions were launched in the daytime under the same conditions, and the interval was one week. If the subject was wearing glasses, he or she needed to take them off in either of the two sessions (`play the video and see`).

> Session 1 With Glasses



> Session 2 No glasses



The acquired iris image sequences were captured at 5~10 frames per second. The resolution of each frame was 3840x2748. The frames in which irides were completely invisible caused by blinking or squinting were thrown away. Then evenly spaced images are extracted from the processed sequence every 5 frames. On average, approximately 20 images of each subject were retained.

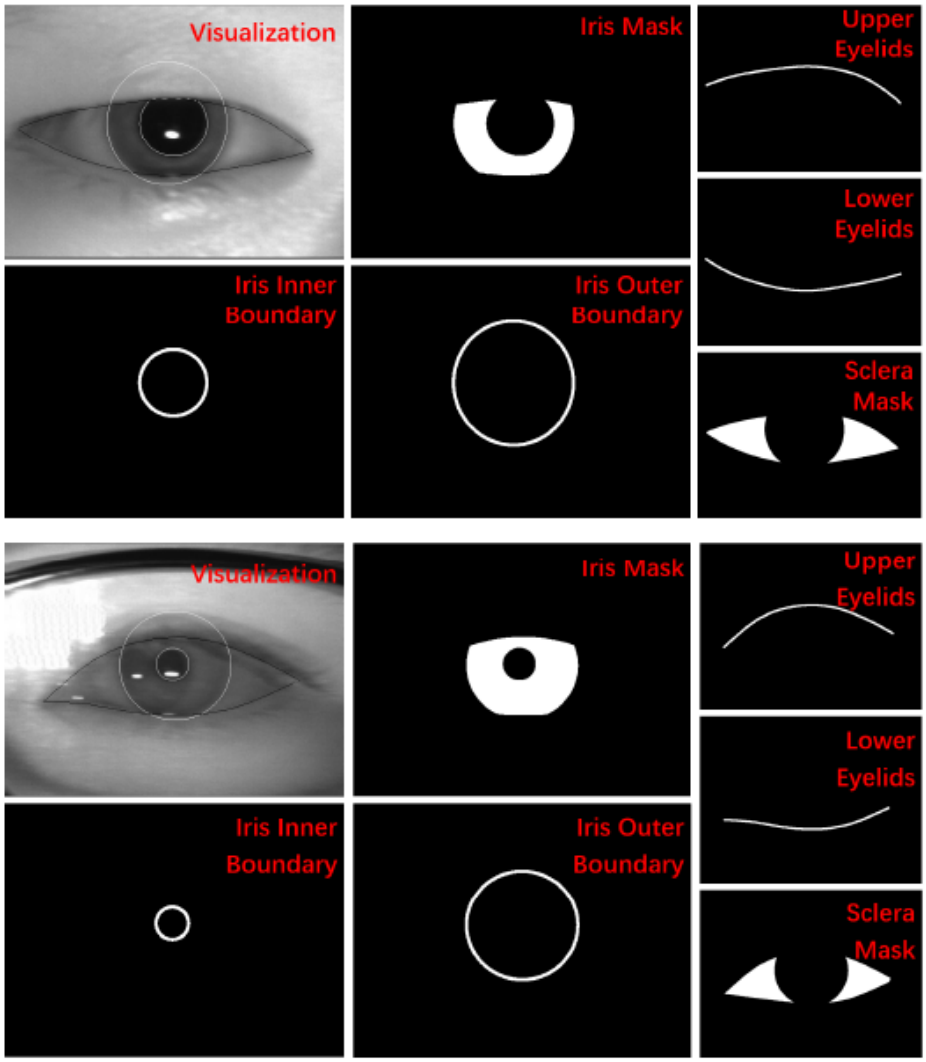
Statistics of the dataset

Attributes	The database
Camera Type	CASIA-LR-Cam II
Illumination	NIR and natural lighting sources
Total pixel	3840x2748
Cropped eye region	640x480
Sessions	Two separate sessions
Institution of subjects	Graduate students and staff of CASIA and TAfIRT
Standoff distance	1.0~1.4m
Working mode	Step freely within a moderate square area
Depth of field	ca. 20cm
No. of subjects	98
No. of Classes	195

Attributes	The database
No. of Images	3,765
Images per class	ca. 19
Pairs of Images	39,418 intraclass and 7,406,312 interclass

Mannual Annotations

Each image in the dataset is manually annotated with binary maps of iris masks, inner and outer iris boundaries, upper and lower eyelids, and sclera masks shown as below.



Evaluation Toolkit

IrisStat_V3.0.rar

The package of evaluation toolkit is organized as below.

```
IrisIQA
|
└──config/
|
└──out/
|
└──utils/
```

```
|     computeMotionblur.m
|     computeSharpness.m
|     ini2struct.m
|     Integral.m
|     progressbar.m
|     struct2ini.m
|
└──MotionBlur_Main.m
|
└──Sharpness_Main.m


Segmentation
|
└──config/
|
└──out/
|
└──utils/
|    evalSeg.m
|    Hausdorff.m
|    ini2struct.m
|    progressbar.m
|    struct2ini.m
|
└──IrisSeg_Main.m

Recognition
|
└──config/
|
└──out/
|
└──utils/
|     ACC.m
|     Bitshift.m
|     colors.mat
|     compute_iriscode_sim.m
|     compute_om_sim.m
|     compute_vector_sim.m
|     draw_CMC_curve.m
|     draw_DET_curve.m
|     EER.m
|     IdentiACC.m
|     linspecer.m
|     Merge_Multi_CMC_Curve.m
|     Merge_Multi_Det_Curve.m
|     plot_styles.mat
|     progressbar.m
|     VerfiACC.m
|
└──IrisRec_main.m
```

- The main function of iris IQA evluating sharpness and motion blur is `Sharpness_Main.m` and `MotionBlur_Main.m`.
- The main function of iris segmentation evaluation is `IrisSeg_Main.m`.
- The main function of iris recogniton evaluation is `IrisRec_Main.m`.

Database Organization

The database package comprises of the following components organised in multiple directories.

```
|
circle_params
|  |
|  └──xxxL(R)_xx.ini
|
ellipse_params
|  |
|  └──xxxL(R)_xx.ini
|
image
|  |
|  └──xxxL(R)_xx.jpg
|
iris_edge
|  |
|  └──xxxL(R)_xx.png
|
iris_edge_mask
|  |
|  └──xxxL(R)_xx.png
|
iris_edge_rough
|  |
|  └──xxxL(R)_xx.png
|
iris_mask
|  |
|  └──xxxL(R)_xx.png
|
lower_eyelids_edge
|  |
|  └──xxxL(R)_xx.png
|
lower_eyelids_edge_rough
|  |
|  └──xxxL(R)_xx.png
|
pupil_edge
|  |
|  └──xxxL(R)_xx.png
|
pupil_edge_mask
|  |
|  └──xxxL(R)_xx.png
|
pupil_edge_rough
|  |
|  └──xxxL(R)_xx.png
|
pupil_mask
|  |
|  └──xxxL(R)_xx.png
|
pupil_edge_rough
|  |
|  └──xxxL(R)_xx.png
|
pupil_mask
|  |
|  └──xxxL(R)_xx.png
```

```
|
sclera_mask
|   |
|   └──xxxL(R)_xx.png
|
up_eyelids_edge
|   |
|   └──xxxL(R)_xx.png
|
up_eyelids_edge_rough
|   |
|   └──xxxL(R)_xx.png
|
vis_result
|   |
|   └──xxxL(R)_xx.png
|
vis_result_new
|   |
|   └──xxxL(R)_xx.png
|
imgList.txt
```

The file naming rule is "`xxxL(R)_xx`", where "`xxx`" denotes the unique identifier of the subject, "`L`" denotes left eye and "`R`" denotes right eye and "`xx`" denotes the index of the image in the class, e.g., `001L_01`. All the filenames of the iris images and belonging classes are stored in `imgList.txt`.

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To receive a copy of the database, a non-student researcher must manually sign the License Agreement and agree to observe the restrictions. The signed document should be digitized and sent through email to: sir@cripac.ia.ac.cn