Iris Segmentation in Challenging Conditions

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Introduction

Why iris?

- It is unique for every person
- It almost does not change during the life
- Its image has high informational capacity
- It is hard to counterfeit

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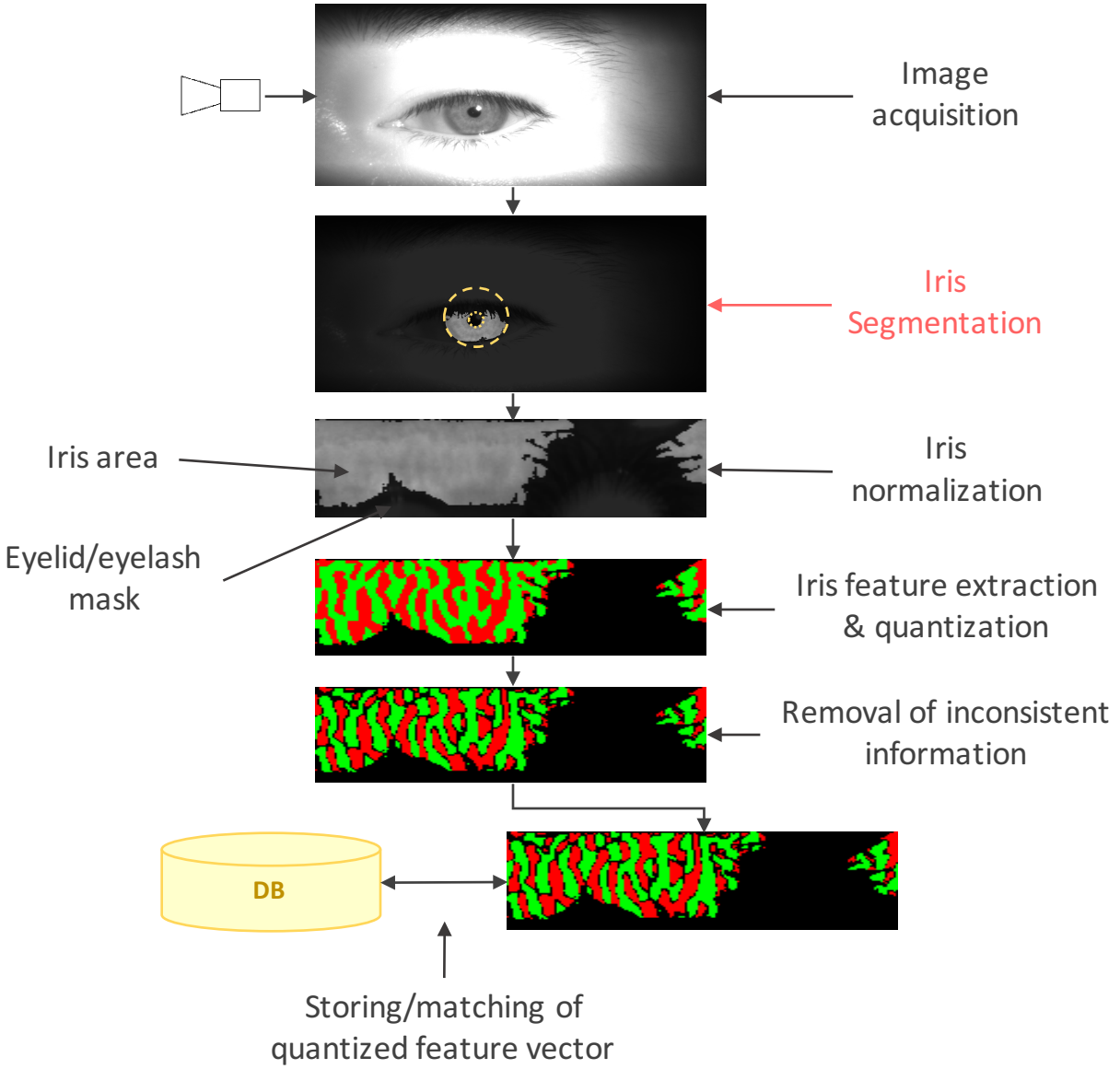

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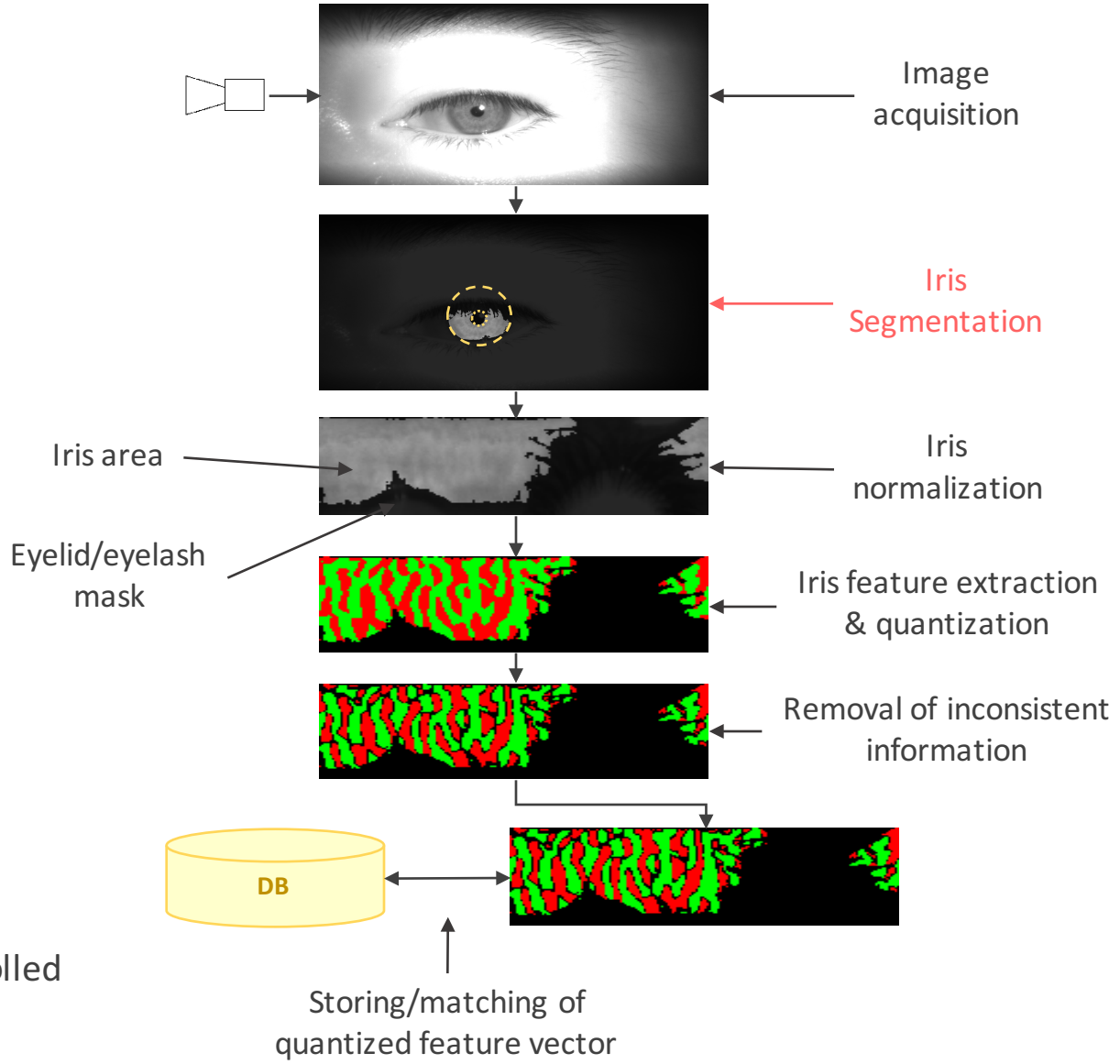
Motivation:

- Segmentation is an irreplaceable stage of iris recognition pipeline
- Quality of segmentation hugely affects overall recognition performance
- Segmentation is still challenging under less controlled environment



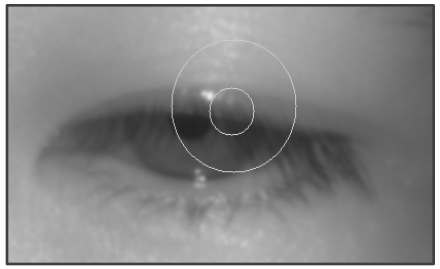
Problem statement

Less controlled environment:

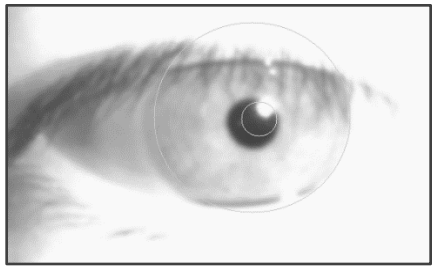
- Conditions:
  - illumination level
  - non-glasses/glasses/contact lenses
- Eye variations:
  - pupil dilation/contraction
  - gaze away
- Iris occlusions:
  - eyelids/eyelashes
- Device performance limitations:
  - CPU, RAM, Camera resolution (mobile)

As the result:

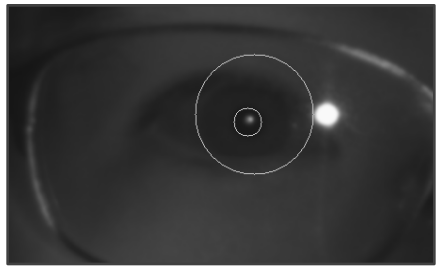
- Image quality degradation:
  - under-/over-exposure
  - poor contrast
  - reflections from glasses
- Segmentation errors:
  - Wrong pupillary/iris/eyelid border determination
- Recognition performance degradation:
  - intra-class variations



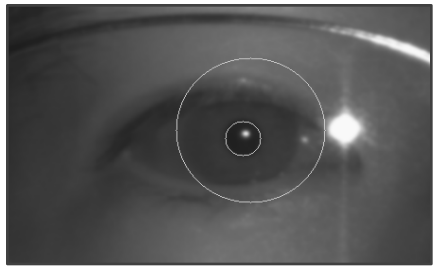
gaze-away, eyelid occlusion



overexposure



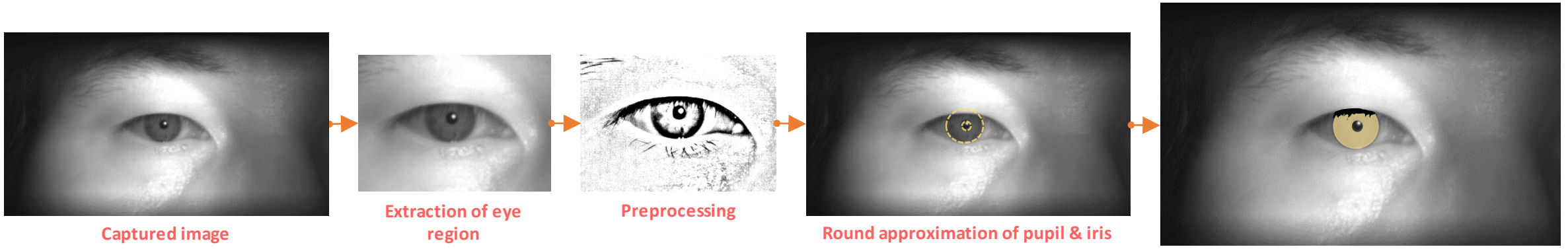
under-illumination, glass reflection



poor contrast, glass reflection

Existing approaches

Common (since 1993, J. Daugman):



Captured image → Extraction of eye region → Preprocessing → Round approximation of pupil & iris → Eyelid & eyelash detection

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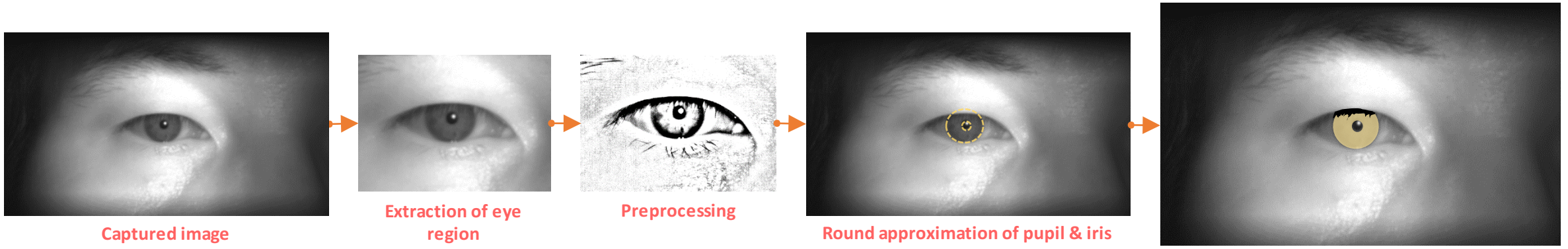

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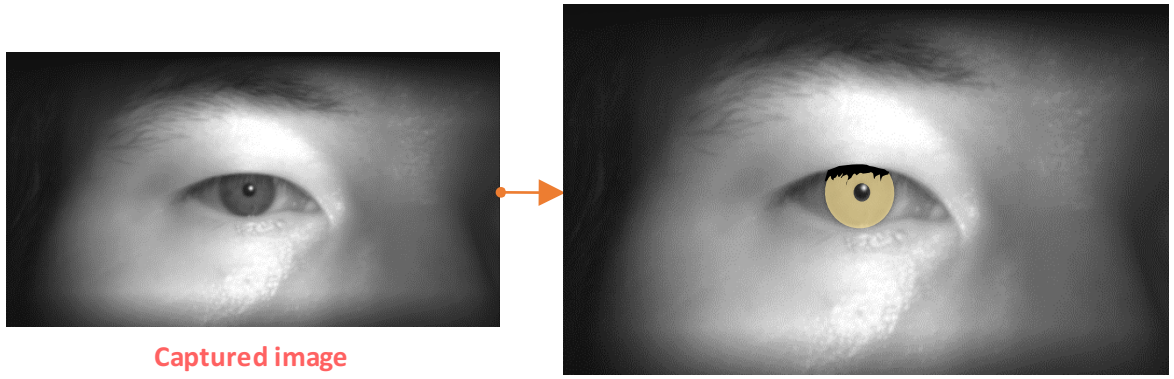
CNN based (end-to-end):



Captured image → Eyelid & eyelash detection

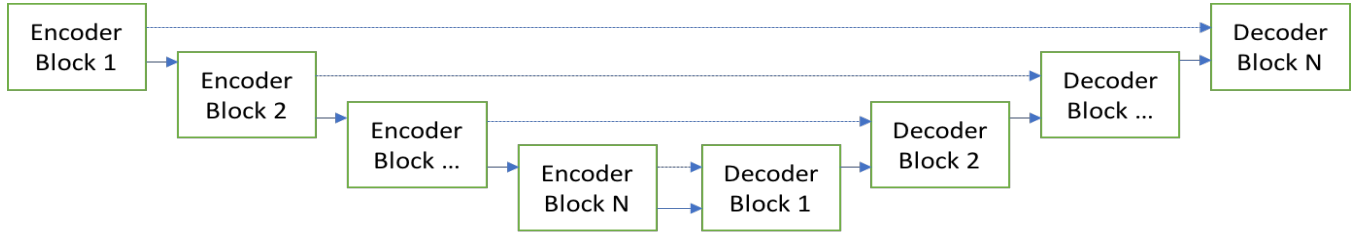
Liu et al. 2016

Method	UBIRIS.v2 error(%)	CASIA.v4 error(%)
Ours MFCNs	**0.90**	**0.59**
Ours HCNNs	1.11	1.08
Z. Zhao and A. Kumar, ICCV, 2015 [33]	1.21	0.68
T. Tan *et al.*, IVC, 2009 [28]	1.31	-
C. Tan and A. Kumar, T-IP, 2013 [27]	1.72	0.81
H. Proença, T-PAMI, 2010 [19]	1.87	-
C. Tan and A. Kumar, T-IP, 2012 [26]	1.90	1.13

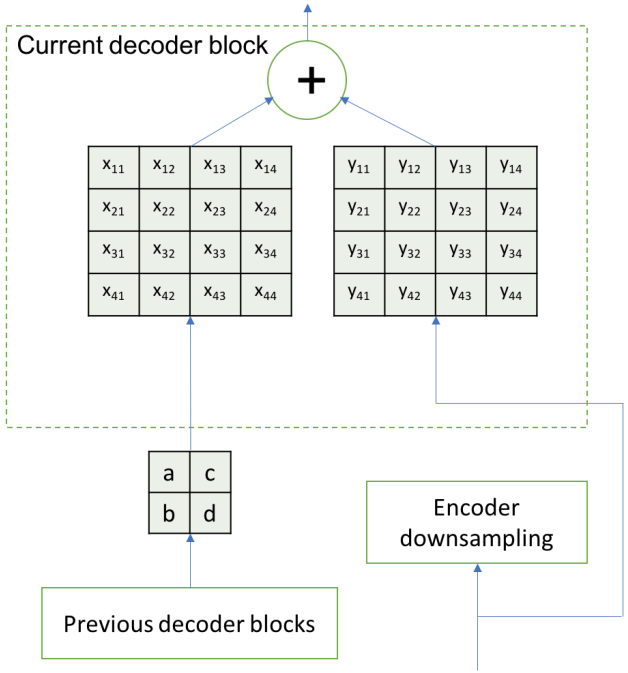
$$error = \frac{1}{N \times m \times n} \sum_{i,j \epsilon (m,n)} G(i,j) \oplus M(i,j)$$

Review: Segmentation Networks

Encoder-Decoder scheme



FCN



costly deconvolutions

memory consumption

(storing all feature maps from encoder)

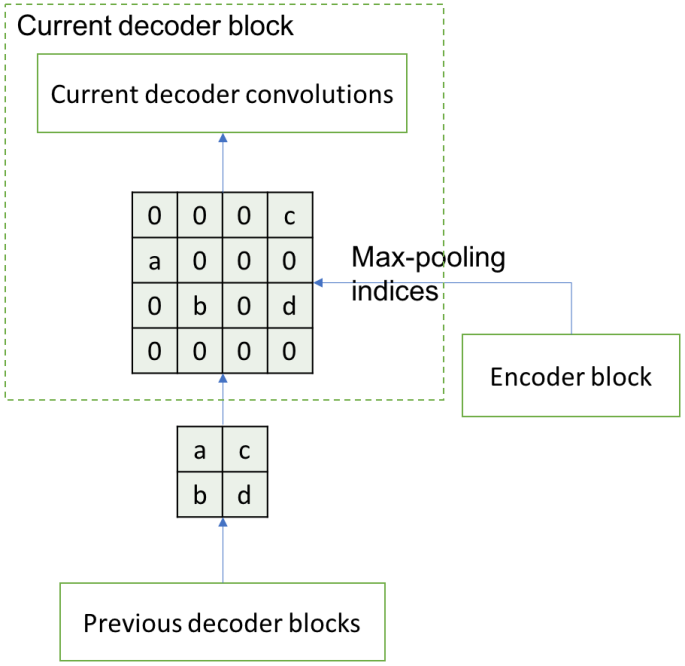
SegNet

fast un-pooling

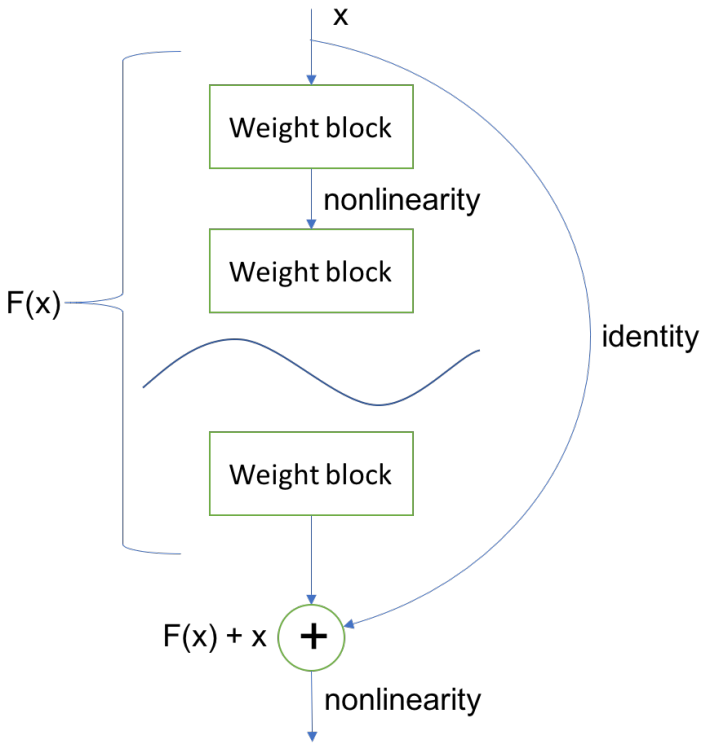
less memory consumption

(storing only indices)

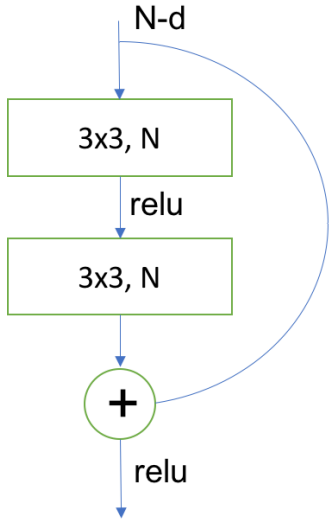
less capacity



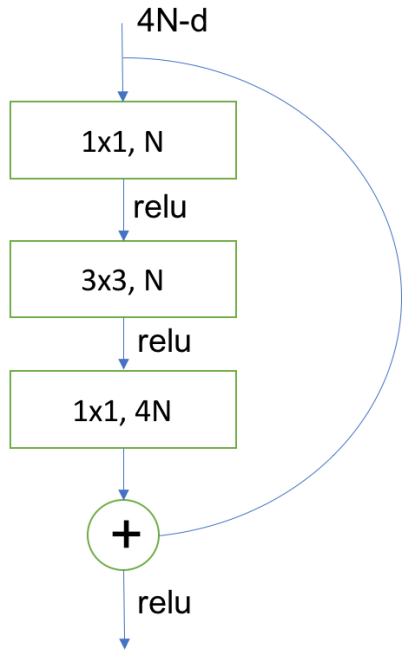
Proposed approach: Internal Block Design



ResNet block
(memory efficient, capacious)



simple ResNet block



bottleneck ResNet block

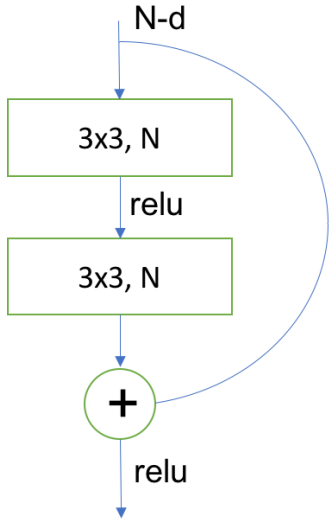
Proposed approach: Network Design

FCN (re-designed):

- Composed with bottleneck ResNet blocks
- Encoder: ResNet-26
- Decoder: original with redesigned blocks

SegNet (re-designed):

- Composed with simple ResNet blocks
- Encoder: ResNet-18
- Decoder: reflected encoder



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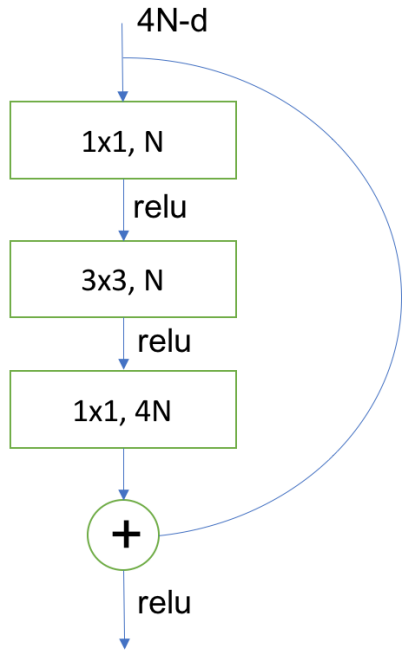

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Experimental results

Dataset description:

- **Name:** CASIA-Iris-Lamp-V3
- **Images (used/total):** 4865/16212
- **Subjects (used/total):** 124/411
- **Labeling:** marking by an expert with the condition
  - Condition: all the pixels of iris area on the image except eyelashes that overlap iris are considered as belonging to iris
- **Division (train/val/test):** 3386/478/1001
- Only the training subset is used for optimization
- **Modified dataset** – same as above but the following changes were applied to every image in the set for training:
  - Random contrast in the range [50%;150%]
  - Random brightness in the range [-20%;20%]

Measure:

- **Jacard Index** (intersection over Union, IoU)

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- **Library/Epochs/Optimizer:** TensorFlow/200/Adam

Segmentation results:

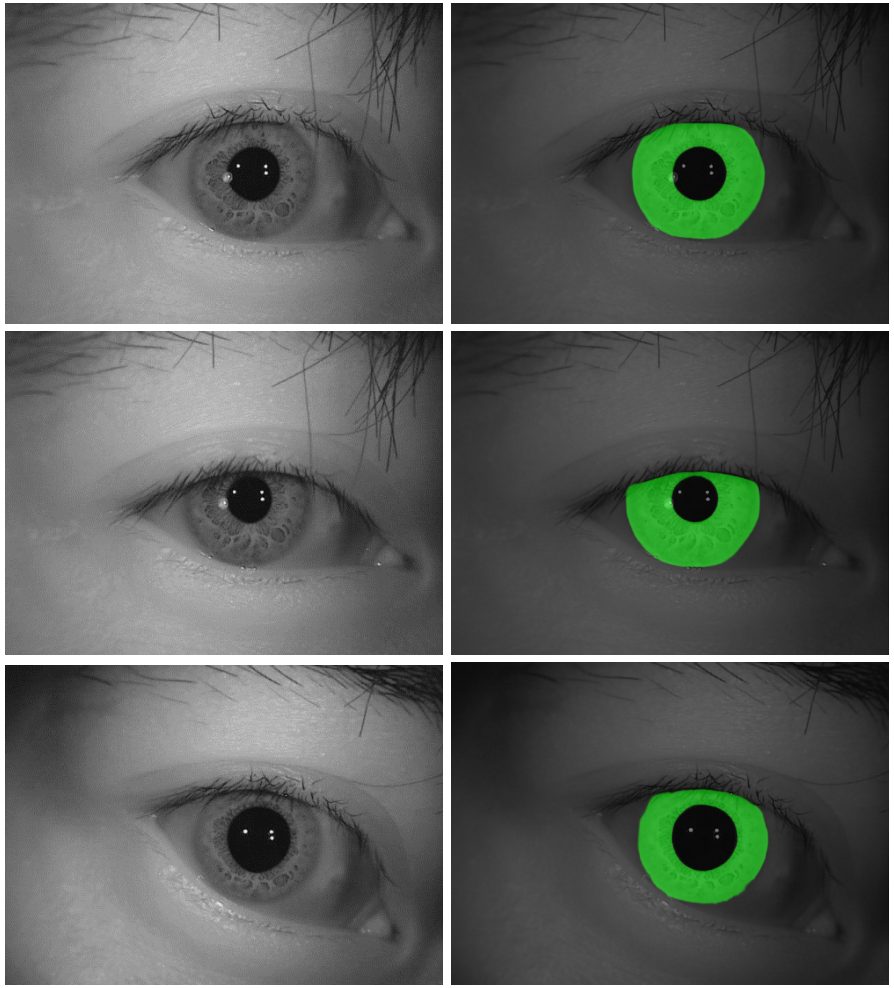
Network	Original dataset, IoU		Modified dataset, IoU	
	val. set	test set	val. set	test set
MFCN	0.918	0.919	0.668	0.676
FCN	**0.930**	**0.930**	0.884	0.894
SegNet	0.928	0.929	**0.916**	**0.924**

Summary:

- **Original dataset:** both FCN and SegNet showed equally well results slightly outperforming MFCN
- Modified **dataset:** both FCN and SegNet outperform MFCN by far

Experimental results: some examples

CASIA-Iris-Lamp-V3 (test set)



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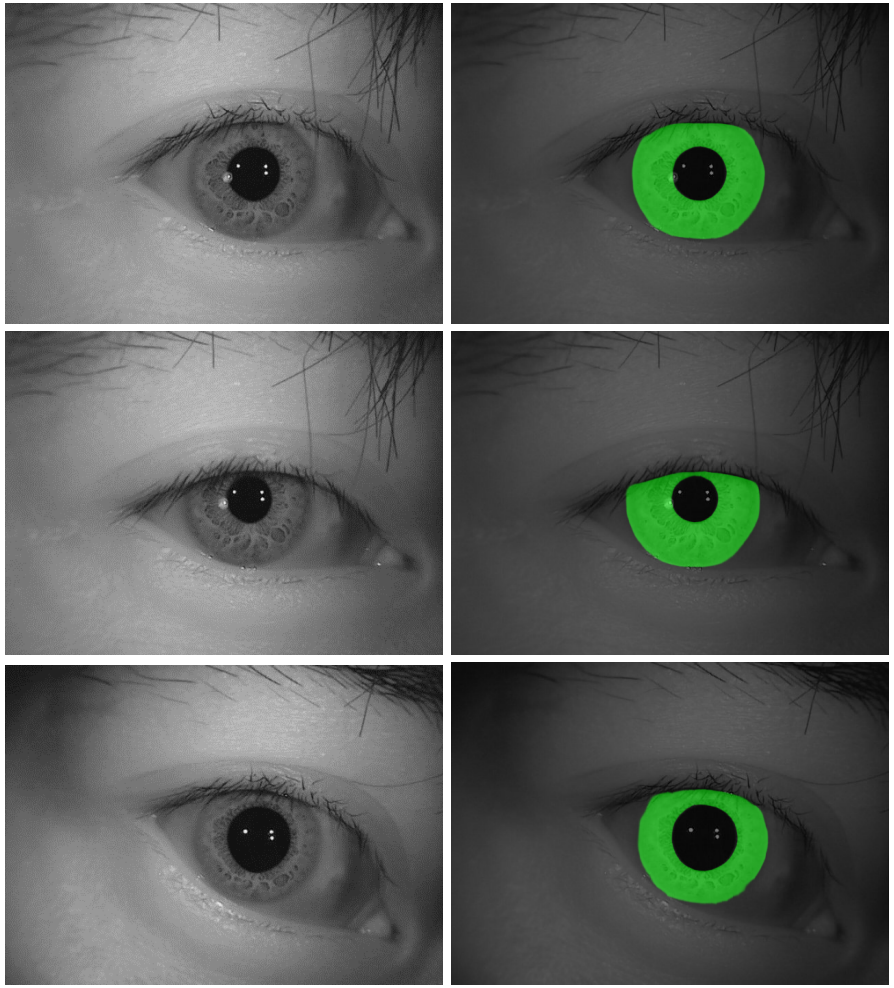
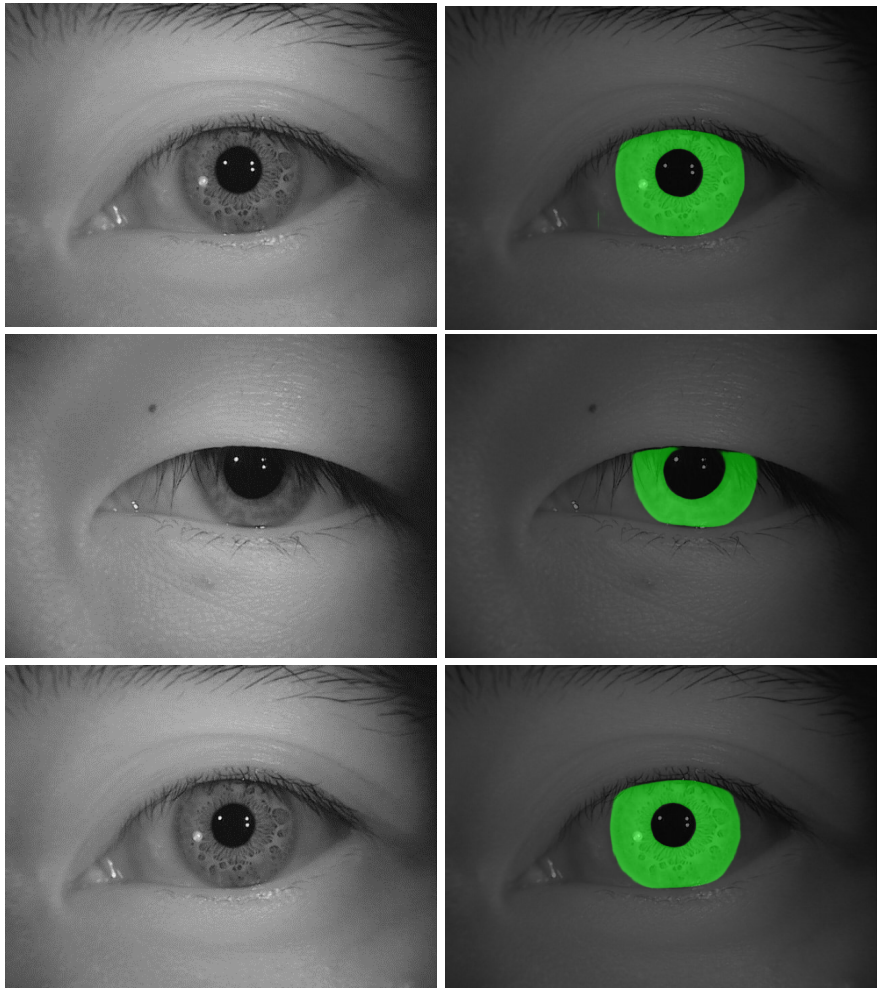


CASIA-Iris-Lamp-V3 (test set)



Experimental results: more examples

Random image from CASIA-Iris-V4 (yet another dataset)

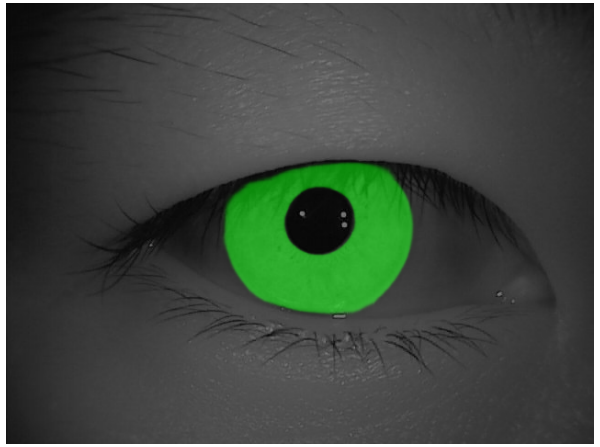
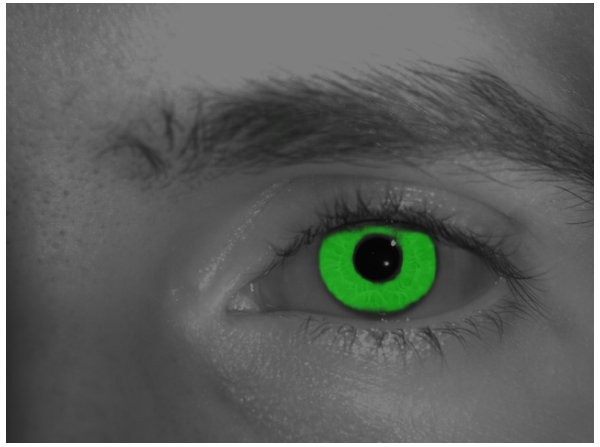
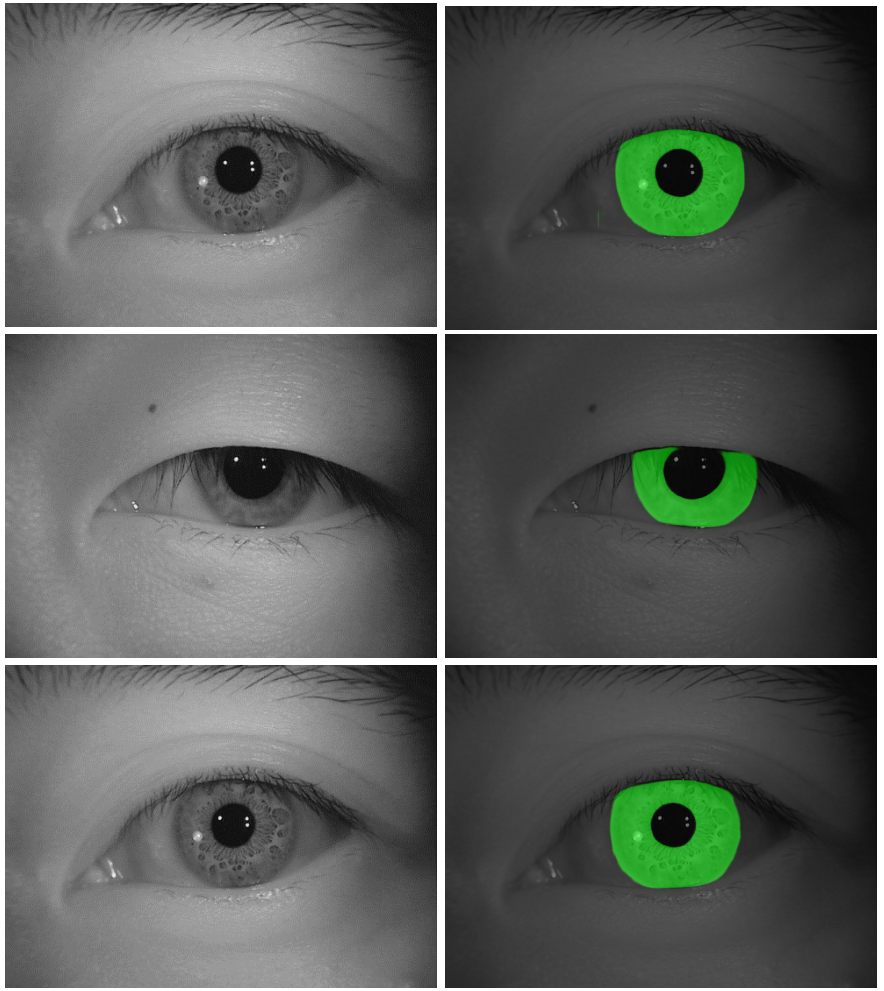


Image captured using Raspberry Pi Camera Board v2.1 (yet another dataset)



CASIA-Iris-Lamp-V3 (test set)



Q&A

Thank you