Seminary
Iris Segmentation

BCC448 – Pattern Recognition

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Paper

- “Robust Iris Segmentation Based on Learned Boundary Detectors”

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Paper

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Motivation

- Biological, physical and behavioral characteristics are unique;
- The iris has been studied since 1987;
- Flom and Safir;
- Stability;
- Richness of texture details such as freckles, coronas, crypts, furrows

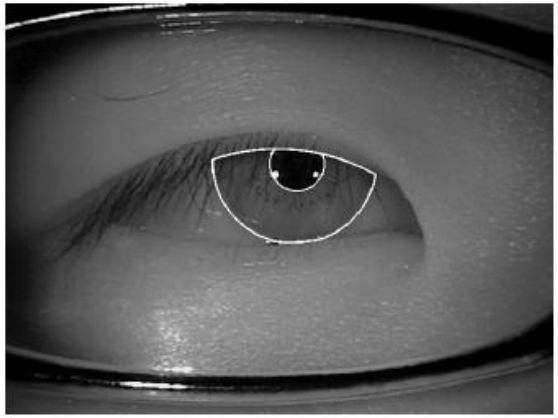
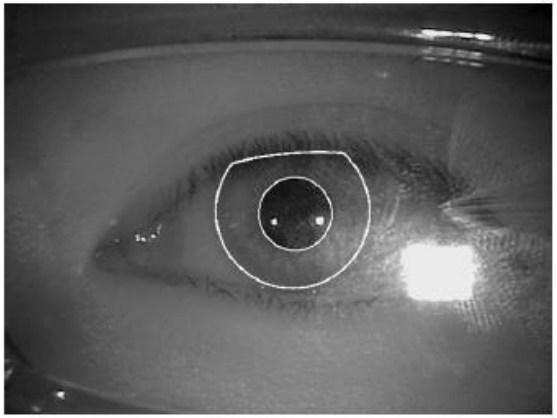
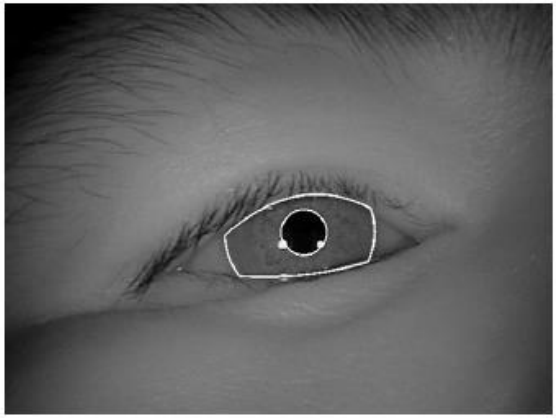
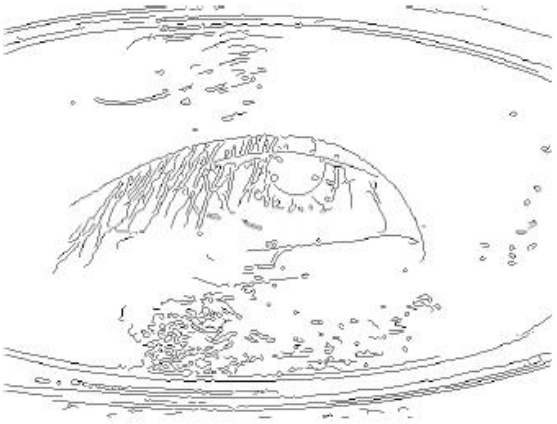
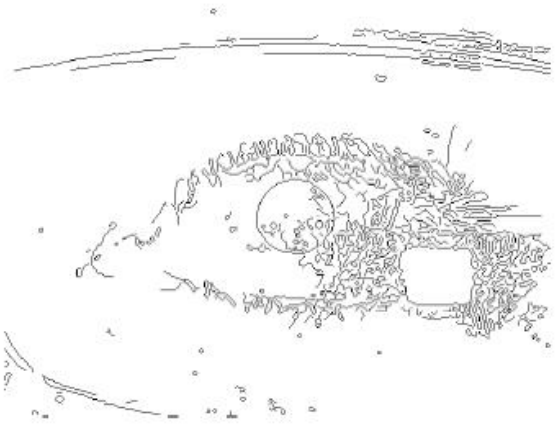
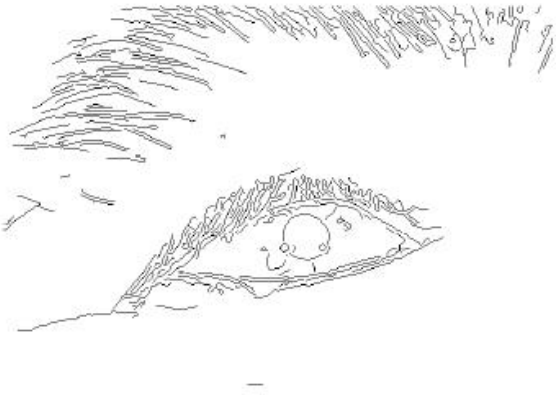
Iris Segmentation

- Isolate the valid iris texture regions;
- State-of-the-art methods are based on edge information
  - Generate a large number of noisy
- Specific edge detectors is proposed

Iris Segmentation

- Method:
  1. Visual features is used to characterize the edge points on iris boundaries;
  2. AdaBoost is employed to learn six class-specific boundary detectors;
  3. Inner and outer boundaries of the iris ring are localized;
  4. The edge points on the eyelids are detected.

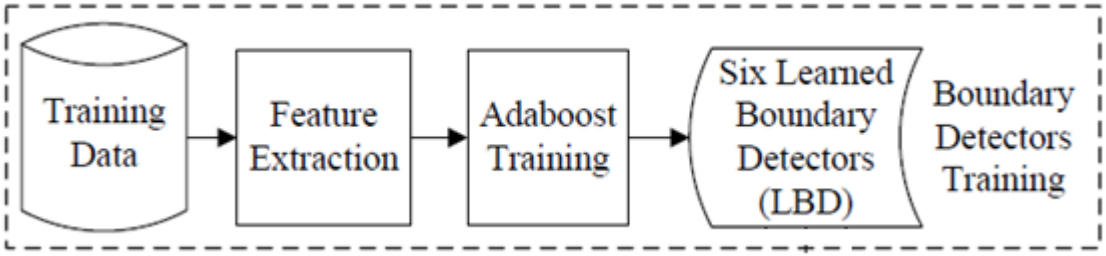
Iris Segmentation

1. Iris Segmentation
2. Canny edge detector

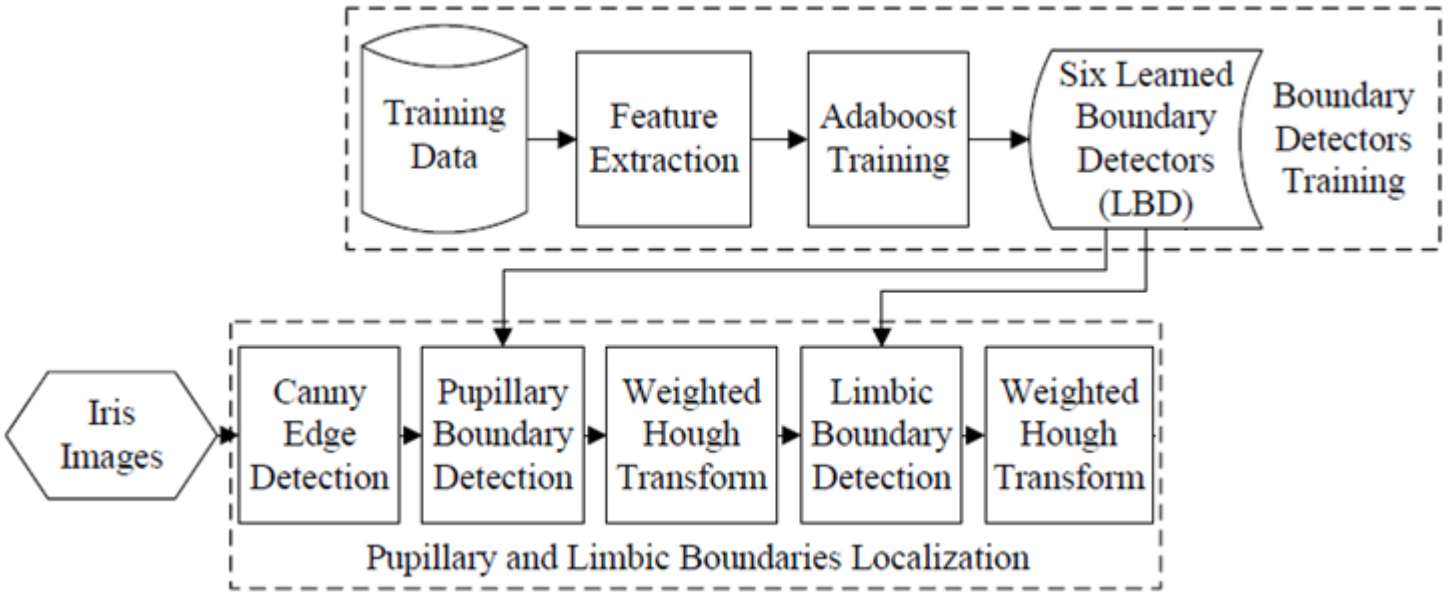
Learned Boundary Detectors

- Three modules:
  - Boundary detectors training;



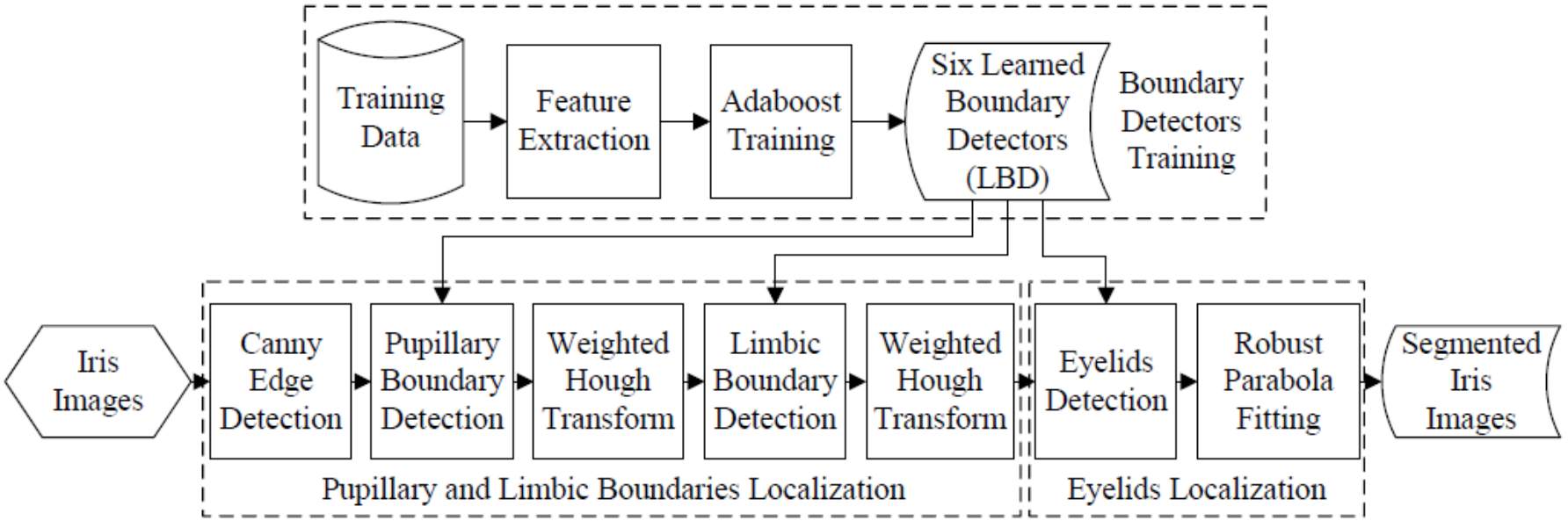
Learned Boundary Detectors

- Three modules:
  - Boundary detectors training;
  - Pupillary and limbic boundaries localization;



Learned Boundary Detectors

- Three modules:
  - Boundary detectors training;
  - Pupillary and limbic boundaries localization;
  - Eyelids localization.



Technical details

- Boundary detectors training
  - Discriminate genuine edge points on iris boundaries from noisy edge points;

- Features:
  - Mean;
  - Variance;
  - Haar-like.

Technical details

- Gentle AdaBoos
  - Use adaptive Newton steps
- The learned strong classifiers will be used as boundary detectors

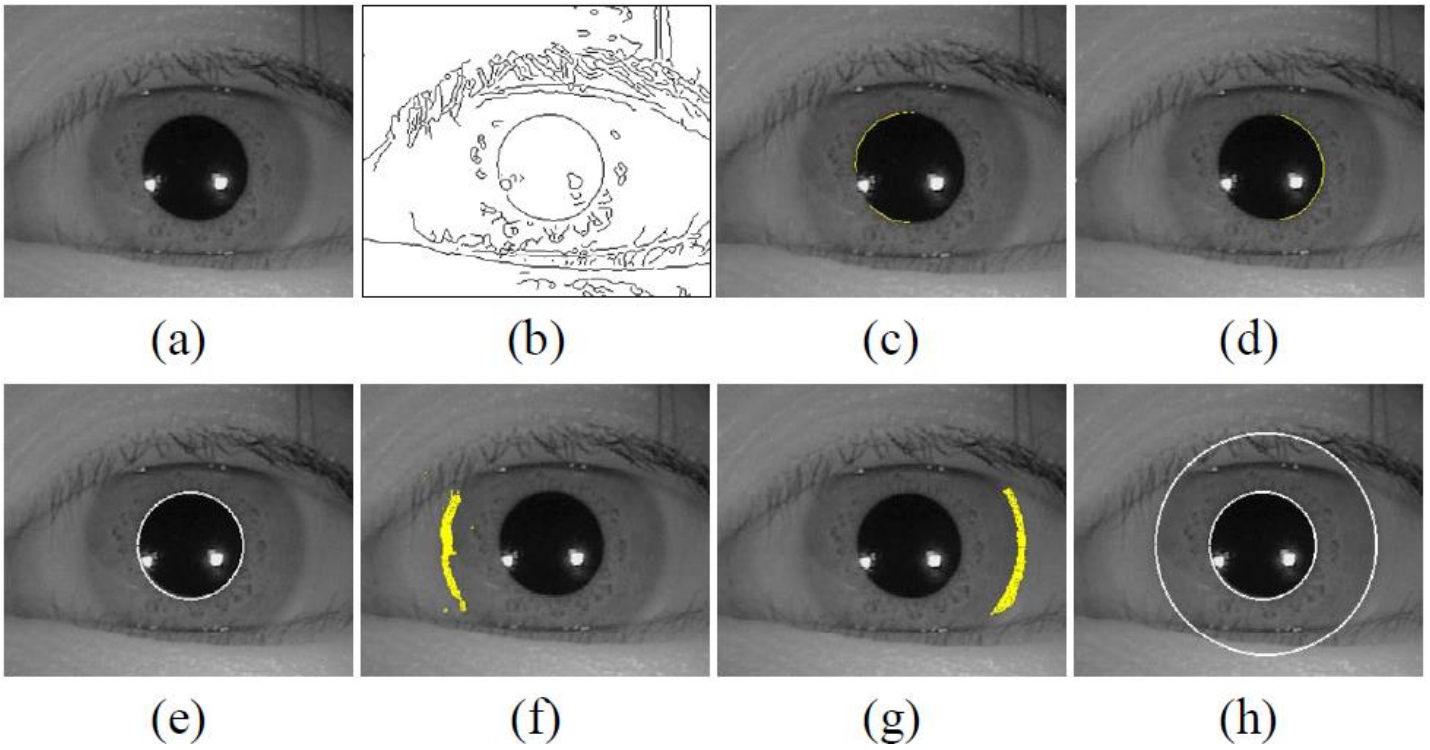
Pupillary and limbic boundaries localization

- Canny edge detector to find the pupillary candidate edge points
  - Problem: Invalid points
  - Solution: Previously learned left and right pupillary boundary.

Pupillary and limbic boundaries localization

- Pupillary and limbic boundaries
  - Modeled as circles
  - parameters are determined by Hough transforms

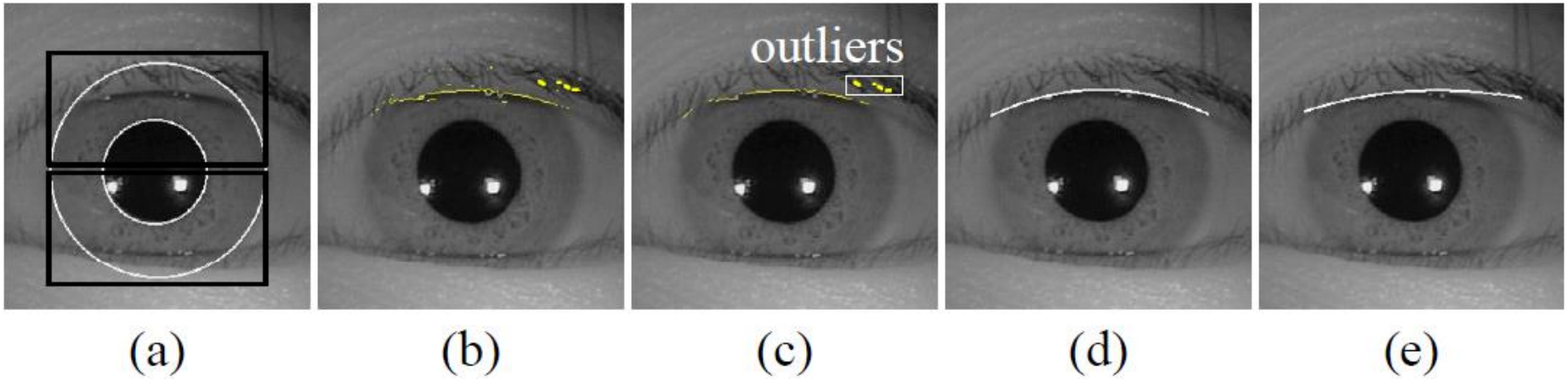
Pupillary and limbic boundaries localization



(a) Original Iris (b)Canny edge image; (c), (d), (f), (g) Yellow pixels are detected by learned left pupillary, right pupillary, left limbic and right limbic boundary detectors respectively; (e), (h) Pupillary and limbic boundaries fitted as circles by weighted Hough transforms.

Eyelids localization

- Not regular as pupillary and limbic boundaries.
- Eyelids detection areas are restricted as in (a)



(a) Localized pupillary and limbic boundaries. The black rectangles are the regions for upper and lower eyelids localization. (b) Yellow pixels are detected by the learned upper eyelid detector; (c) Eyelids points after further noise removal; (d), (e) The upper eyelid is fitted as a parabola

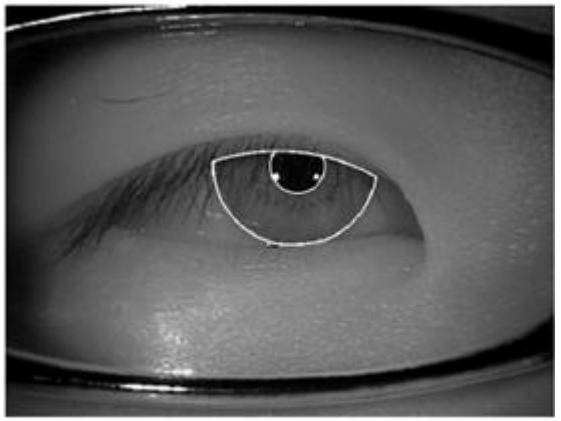
Eyelids localization

- Detect candidate eyelids points
  - Canny
  - low thresholds
  - almost all valid points are included.

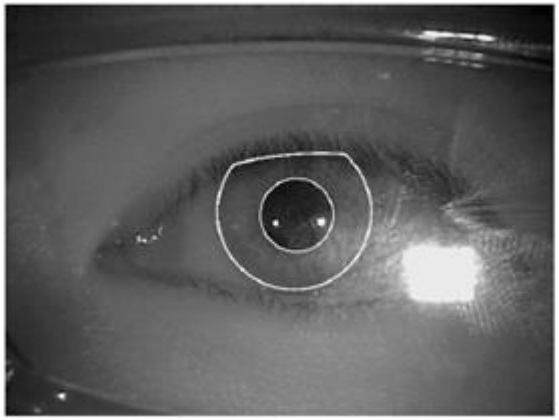
- Previously learned eyelid boundary detectors are employed to test every candidate points.

Experiments

- CASIA-Iris-Thousand database
  - Includes 20,000 iris images
  - 2,000 eyes of 1,000 persons



- Iris segmentation particularly difficult
  - Glasses
  - Large specular reflections and glasses frames



Experiments

- Comparison
  - Learned Boundary Detectors (LBD)
  - State-of-the-art method proposed by He et al.

- Effect of weights in Hough transform, compare:
  - Weighted Hough transforms
  - Hough transforms without weights

Experiments

- Evaluate the accuracy of each method
  - Create benchmarks of pupillary and limbic boundaries manually on the whole database.
    - For an iris we have the center and the radius of the pupil and the same for limbus ($O_{pBen};R_{pBen};O_{lBen};R_{lBen}$).
  - The algorithm generates a center and the radius of the pupil and the same for limbus ($O_{pAlg};R_{pAlg};O_{lAlg};R_{lAlg}$).

Experiments

- Evaluate the accuracy of each method
  - Calculate the difference rate DN between the result obtained by the algorithm and the bench mark;

$$DR = \begin{cases} DR_t & \text{if } DR_t \leq 1 \\ 1 & \text{otherwise} \end{cases},$$

where:

$$DR_t = \max\{DR_{Op}, DR_{Rp}, DR_{Ol}, DR_{Rl}\},$$

in which:

$$DR_{Op} = \|O_{pAlg} - O_{pBen}\|_2 / R_{pBen},$$

$$DR_{Rp} = |R_{pAlg} - R_{pBen}| / R_{pBen},$$

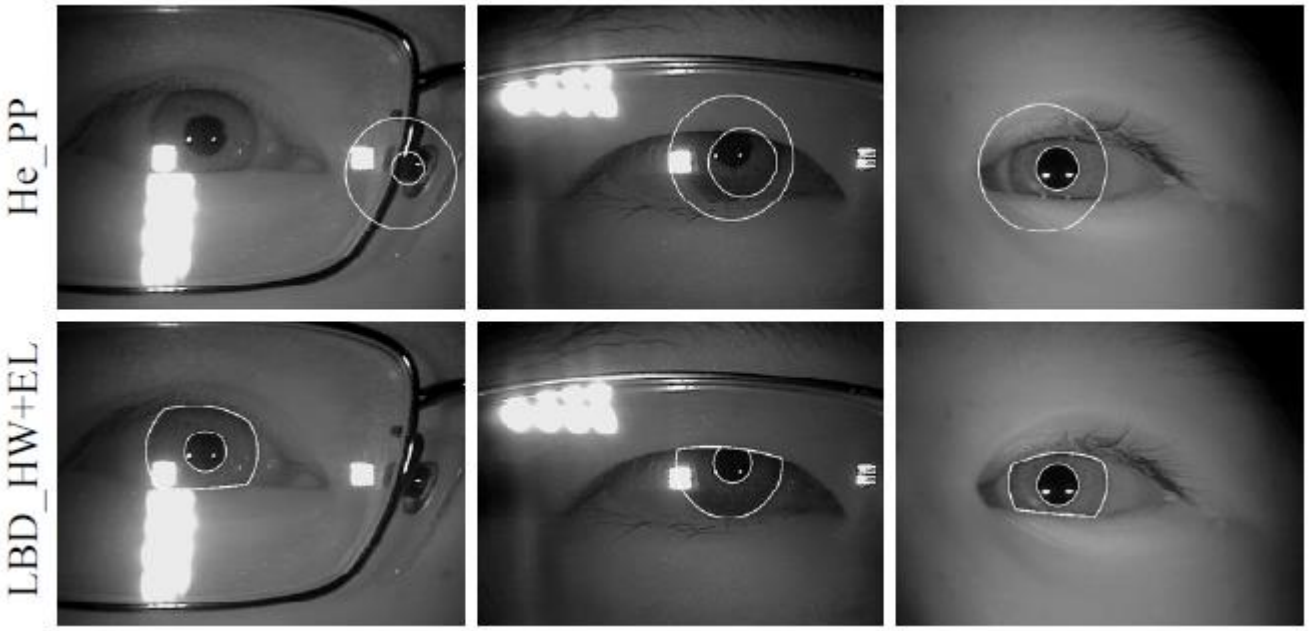
$$DR_{Ol} = \|O_{lAlg} - O_{lBen}\|_2 / R_{lBen},$$

$$DR_{Rl} = |R_{lAlg} - R_{lBen}| / R_{lBen}.$$

$$AR(DR \leq Th) = \frac{\sum_{n=1}^{N} \delta(DR_n \leq Th)}{N}.$$

Where DRn is the DR for then-th image Th is a threshold, N is the total number of tested images

Results



- He_PP: Pupillary and limbic boundaries are localized by the Pulling and Pushing method (PP) proposed by He et al.
- LBD_HW+EL: Eyelids are localized by the proposed eyelids localization method after LBD-HW
- LBD-HW: Weighted Hough transforms are used to determine the parameters of iris rings

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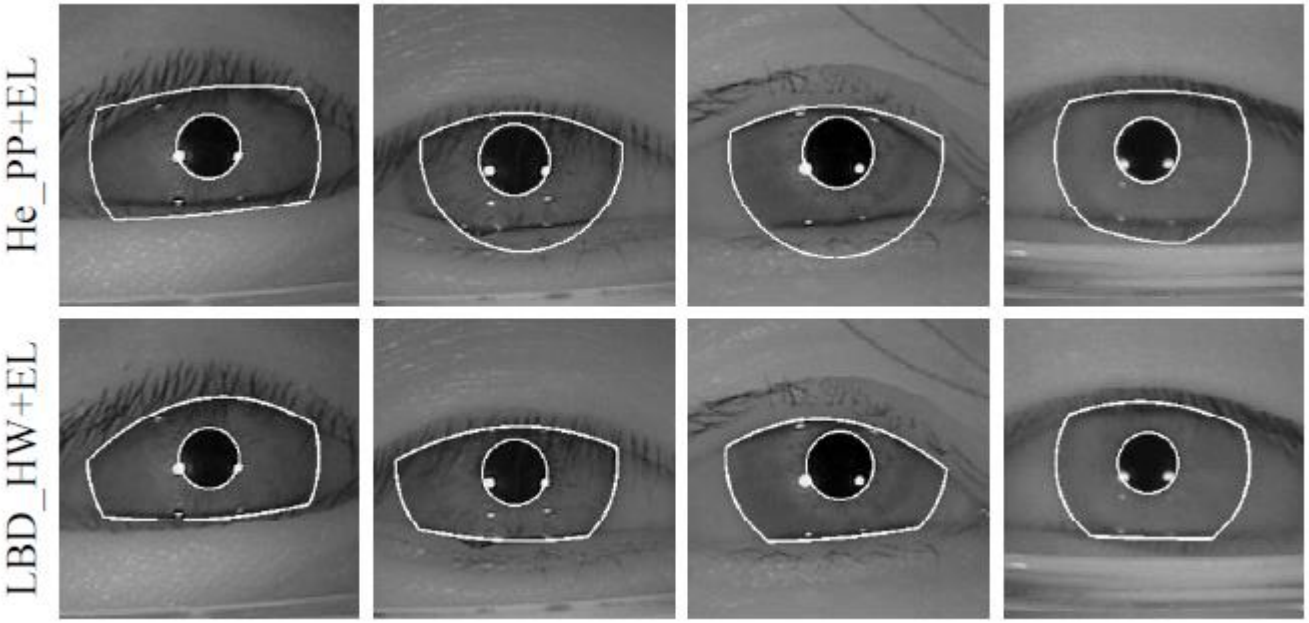

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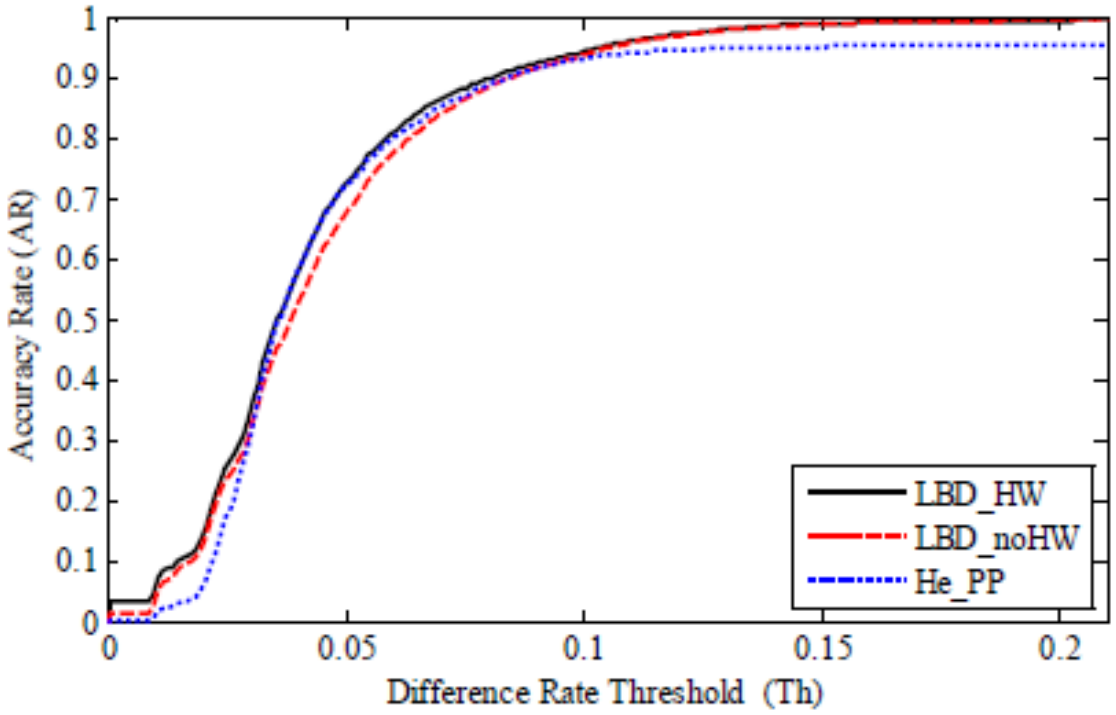

Accuracy rate vs. difference rate threshold on CASIA-Iris-Thousand database

Details of implementation

- Algorithm implemented:
  - MATLAB
- Run:
  - PC with 2.4 GHz CPUs.
- The average time cost per iris segmentation:
  - 4.2s, which is slower than He_PP+EL
- Change accuracy for speed.

Conclusion

- Extensive experiments on the challenging CASIA-Iris-Thousand iris image database have shown the proposed method achieves state-of-the-art iris segmentation accuracy.

- Further work:
  - The proposed method can be improved further. The speed can be accelerated by designing more efficient features and classifiers

Doubts?

References

- Li, Haiqing, Zhenan Sun, and Tieniu Tan. "Robust iris segmentation based on learned boundary detectors." *Biometrics (ICB), 2012 5th IAPR International Conference on*. IEEE, 2012.