



Eyes Wide Open?

Eyelid Location and Eye Aperture Estimation for Pervasive Eye Tracking in Real-World Scenarios

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Introduction

Method

Evaluation

Final Remarks



Eyelids



Eyelids

- Necessary?



Eyelids

- Necessary...
 - Eye maintenance



Eyelids

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 - Eye maintenance
 - Light regulation



Eyelids

- Necessary...
 - Eye maintenance
 - Light regulation
- Evil!
 - Occlusions (pupil, iris...)



Eyelids

- Necessary...
 - Eye maintenance
 - Light regulation
- Evil!
 - Occlusions (pupil, iris...)

- Applications
 - Blink, fatigue, vigilance... [6, 8, 7].



Introduction

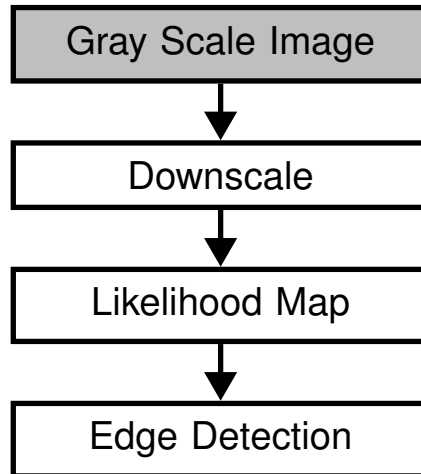
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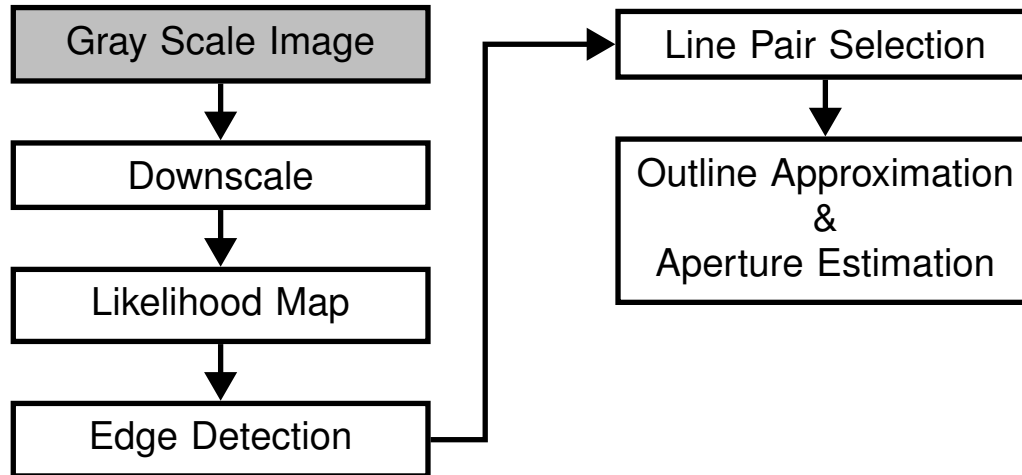


Overview



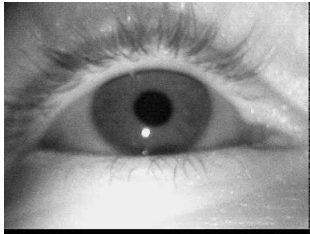


Overview



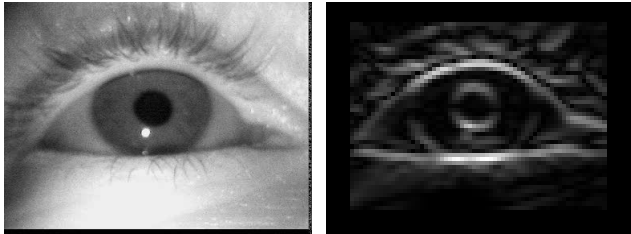


Likelihood Map





Likelihood Map



Prewitt²



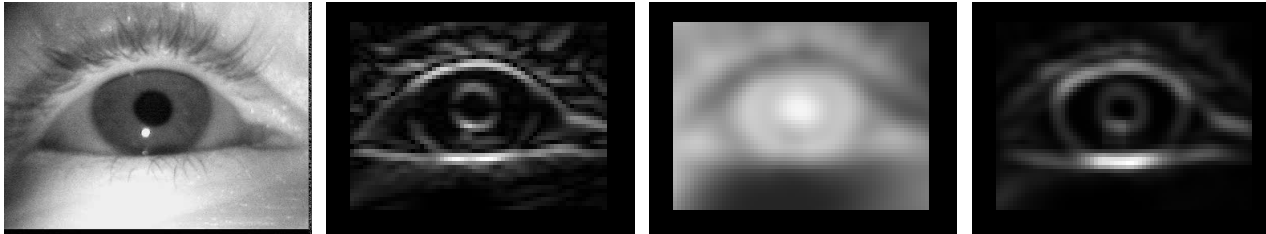
Likelihood Map



$$Prewitt^2 \odot \text{Mean}(\text{Complement})$$



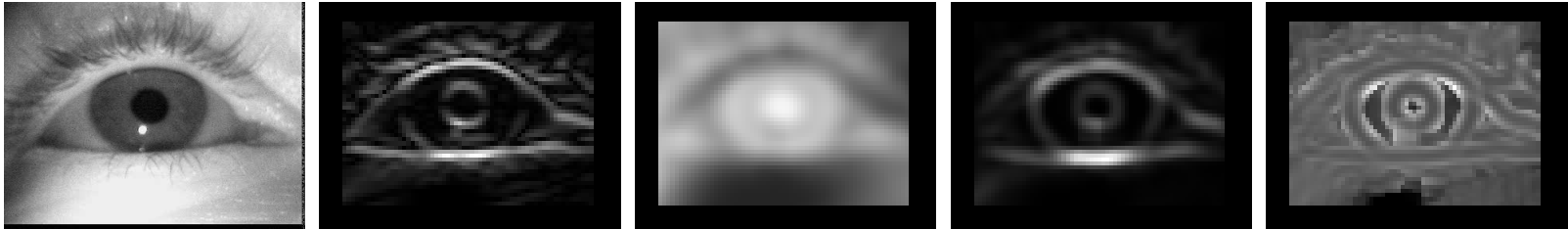
Likelihood Map



$Prewitt^2 \odot Mean(Complement) \odot StdDev$



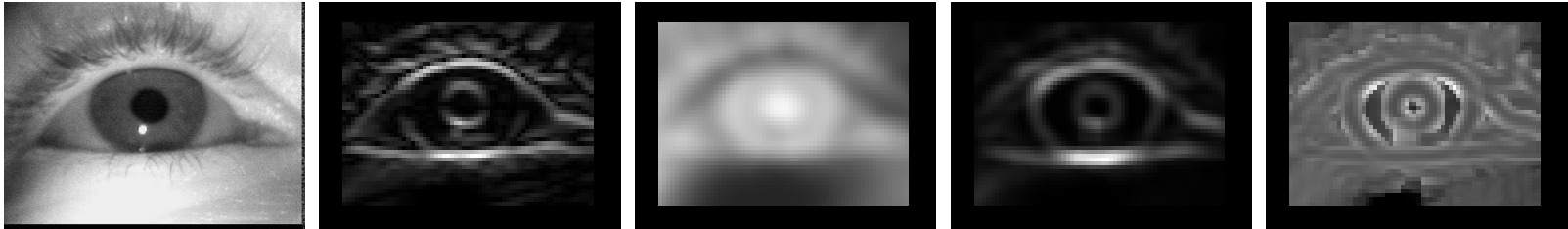
Likelihood Map



Prewitt² ⊙ Mean(Complement) ⊙ StdDev ⊗ Skewness



Likelihood Map

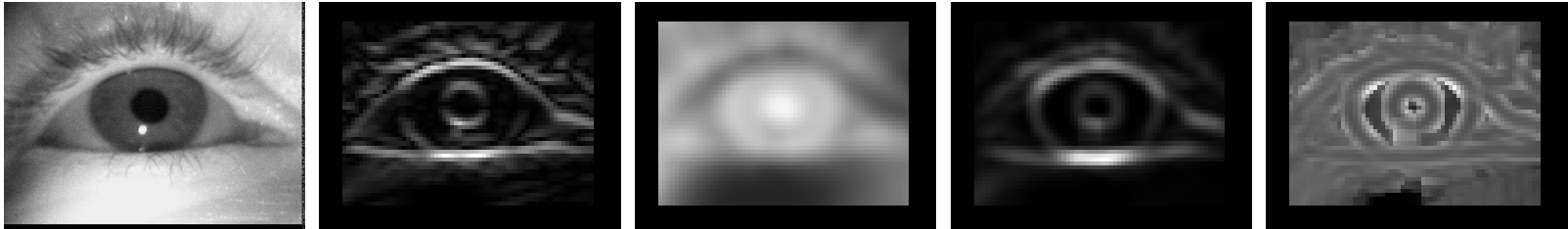


Prewitt² ⊙ Mean(Complement) ⊙ StdDev ⊘ Skewness

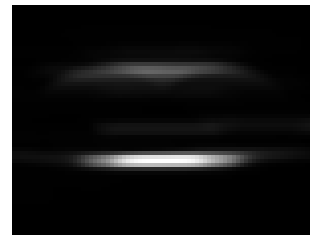




Likelihood Map



Prewitt² ⊙ Mean(Complement) ⊙ StdDev ⊗ Skewness

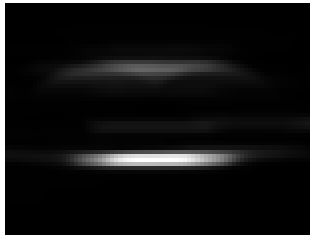


Box Filter → Connect disjoint areas



Edge Detection

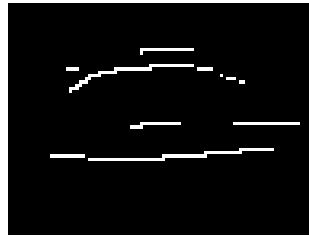
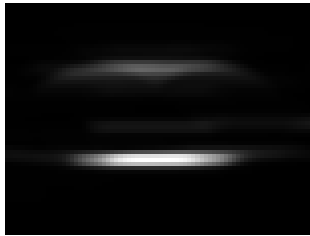
- Non-maxima suppression





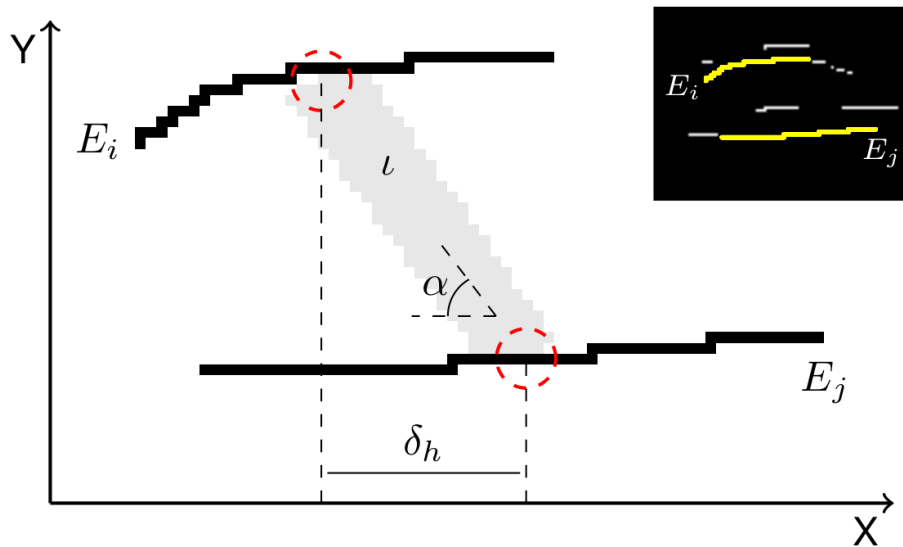
Edge Detection

- Non-maxima suppression



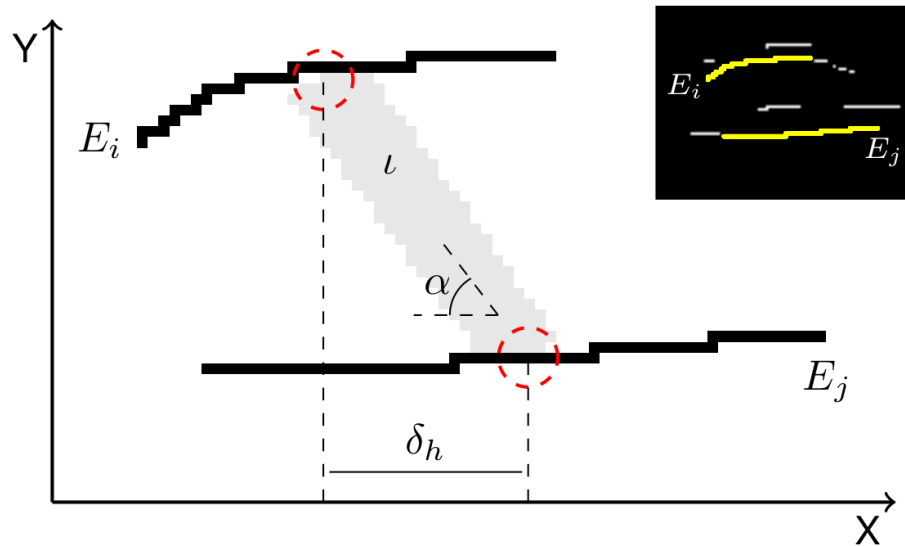


Line Pair Selection





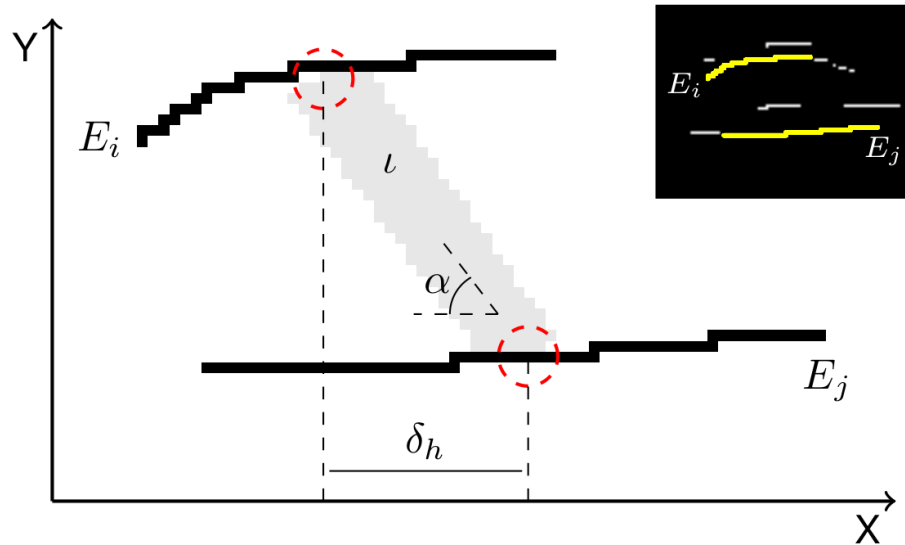
Line Pair Selection



- Horizontal Shift δ_h



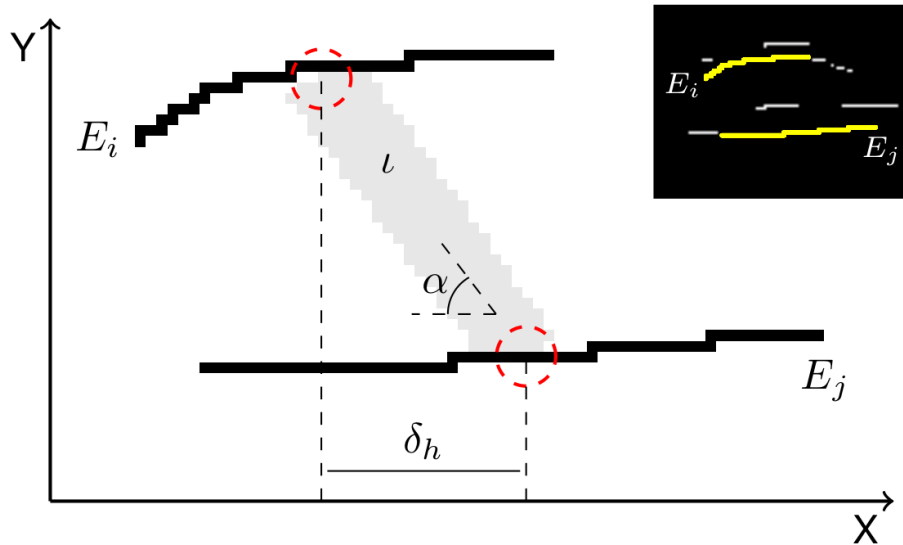
Line Pair Selection



- Horizontal Shift δ_h
- Relative Angle α



Line Pair Selection



- Horizontal Shift δ_h
- Relative Angle α
- Enclosed Intensity ι



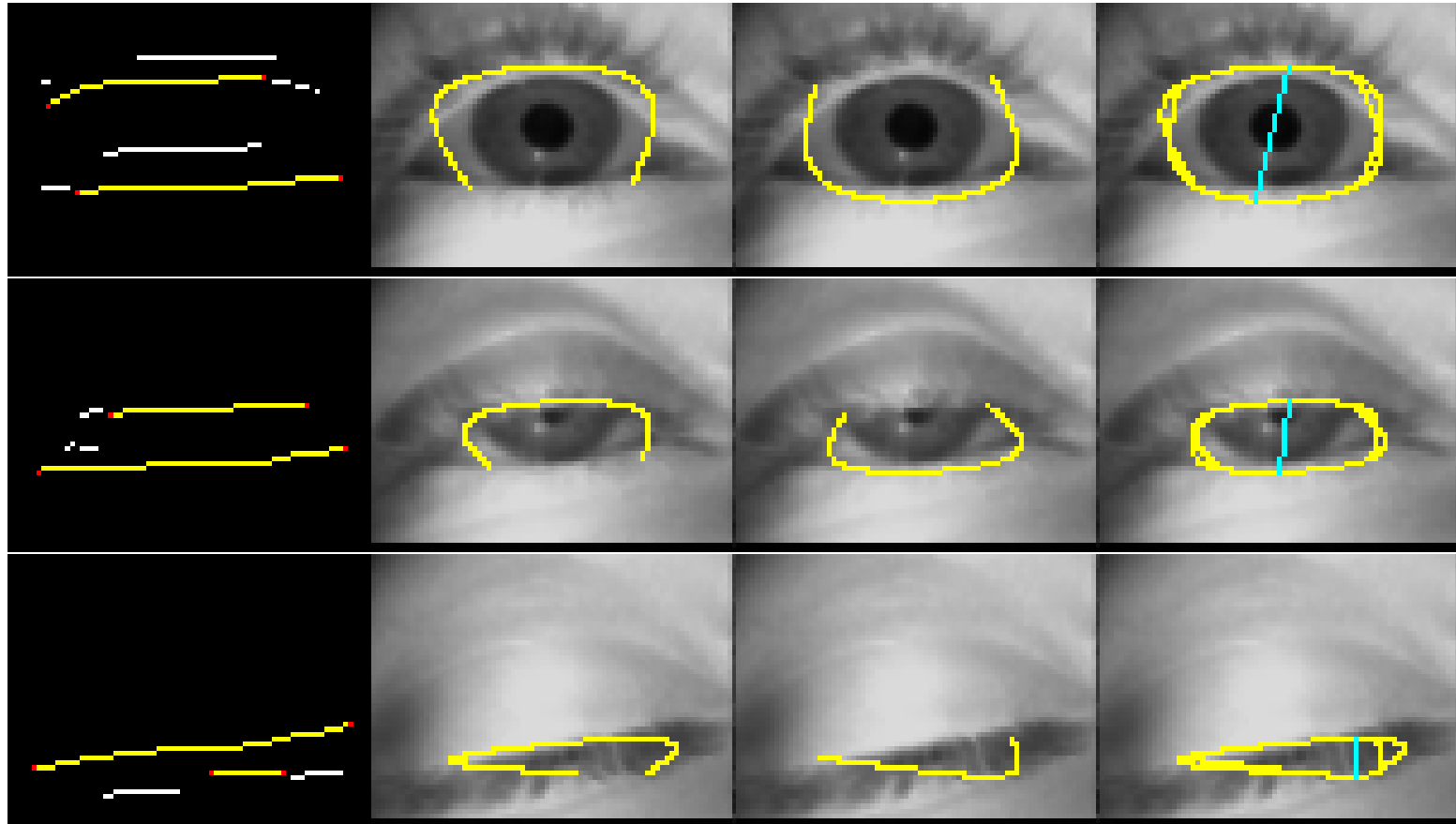
Outline Approximation & Aperture Estimation

Edges

Upper

Lower

Aperture





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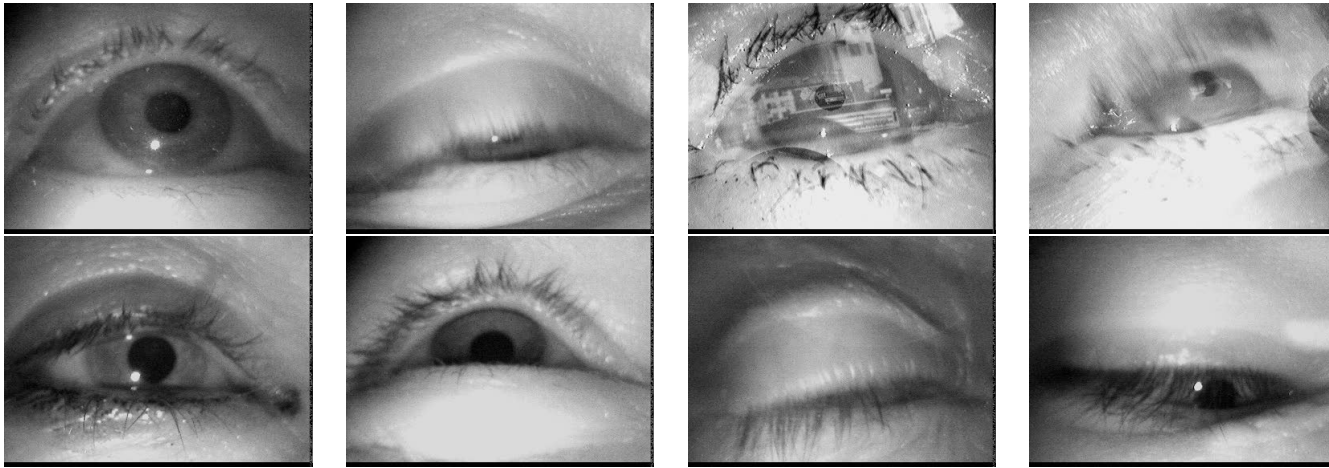
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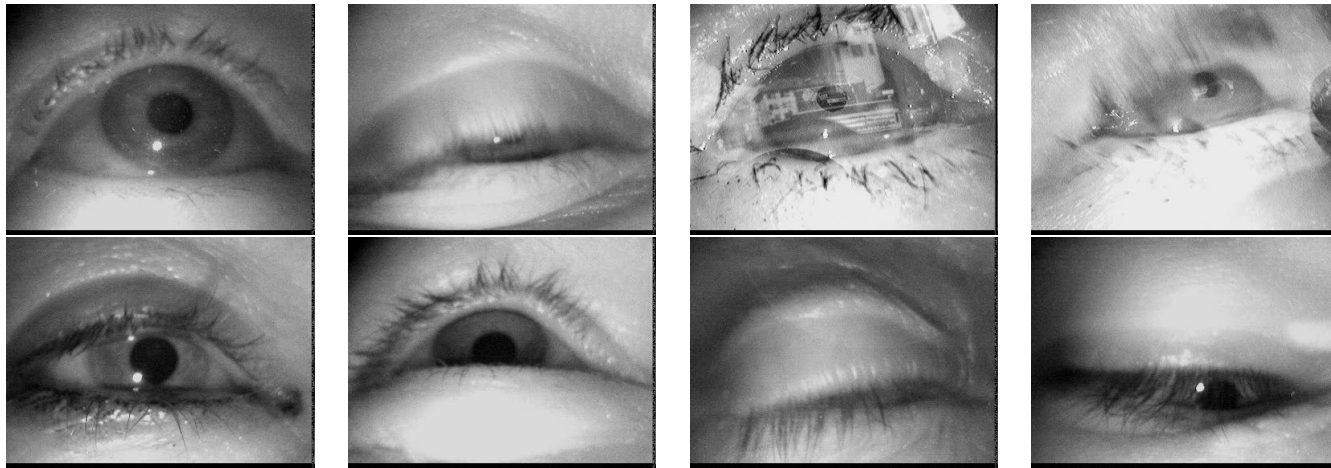


Data Set

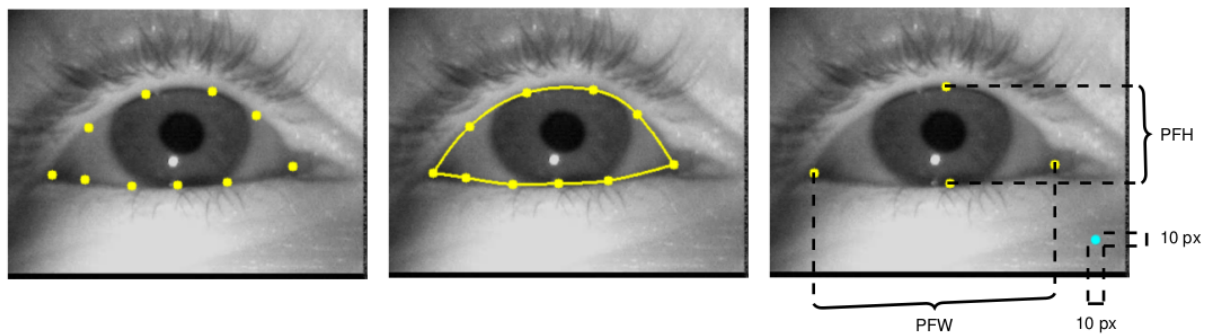




Data Set



1100 hand-labeled images:

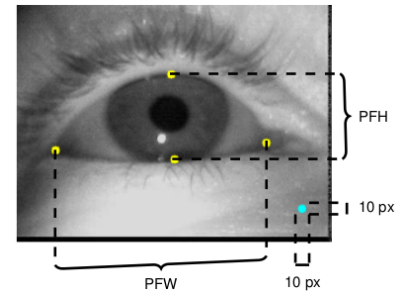


Palpebral Fissure Width (PFW) and Height (PFH) [2]



Aperture Estimation

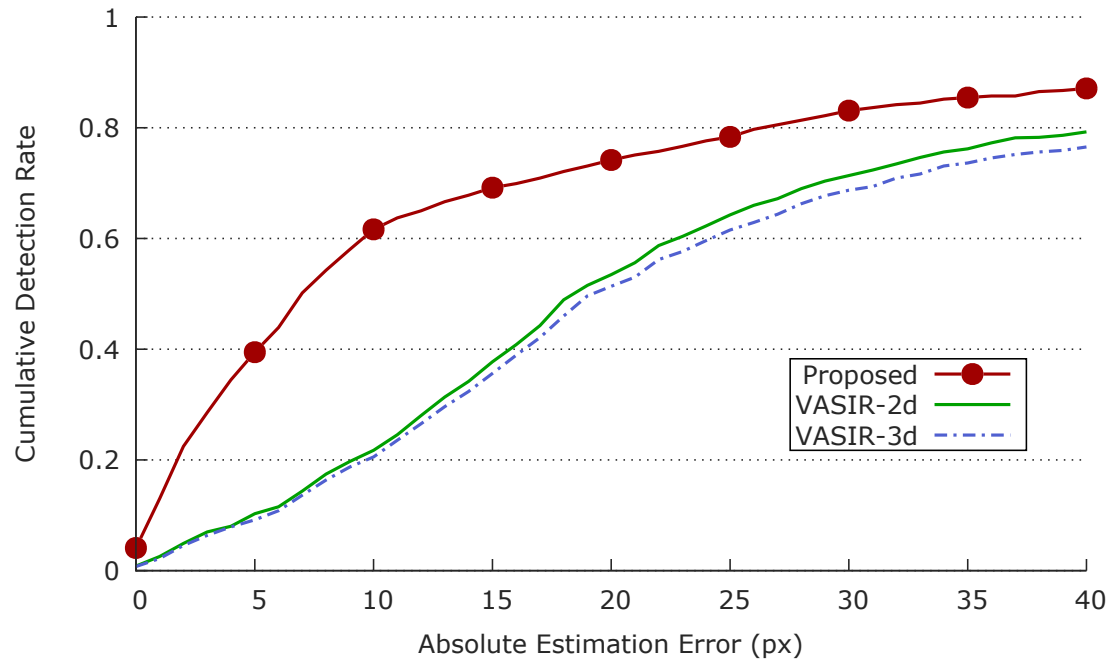
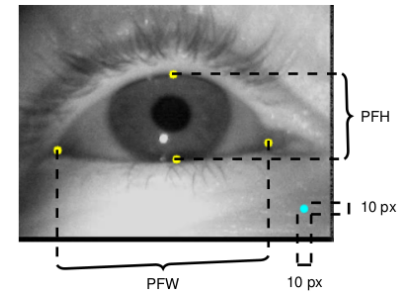
- Error relative to ground-truth PFH
- State-of-the-art: VASIR [5]





Aperture Estimation

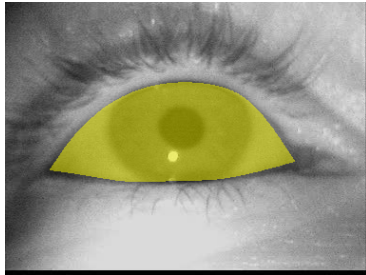
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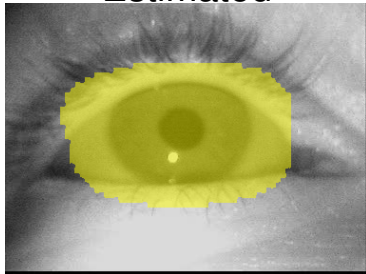


Similarity

Ground Truth



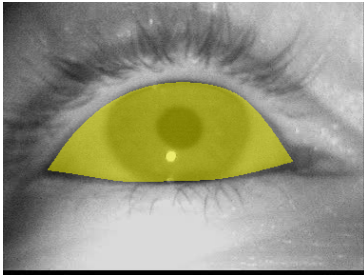
Estimated



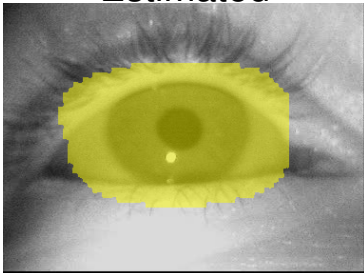


Similarity

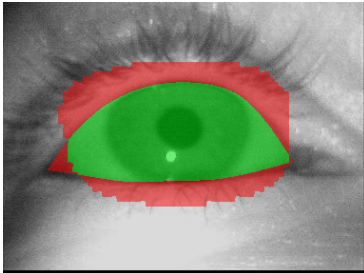
Ground Truth



Estimated



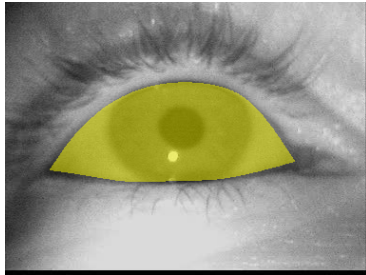
Intersection / Difference



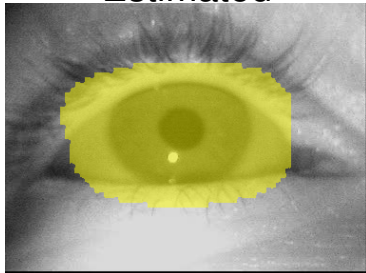


Similarity

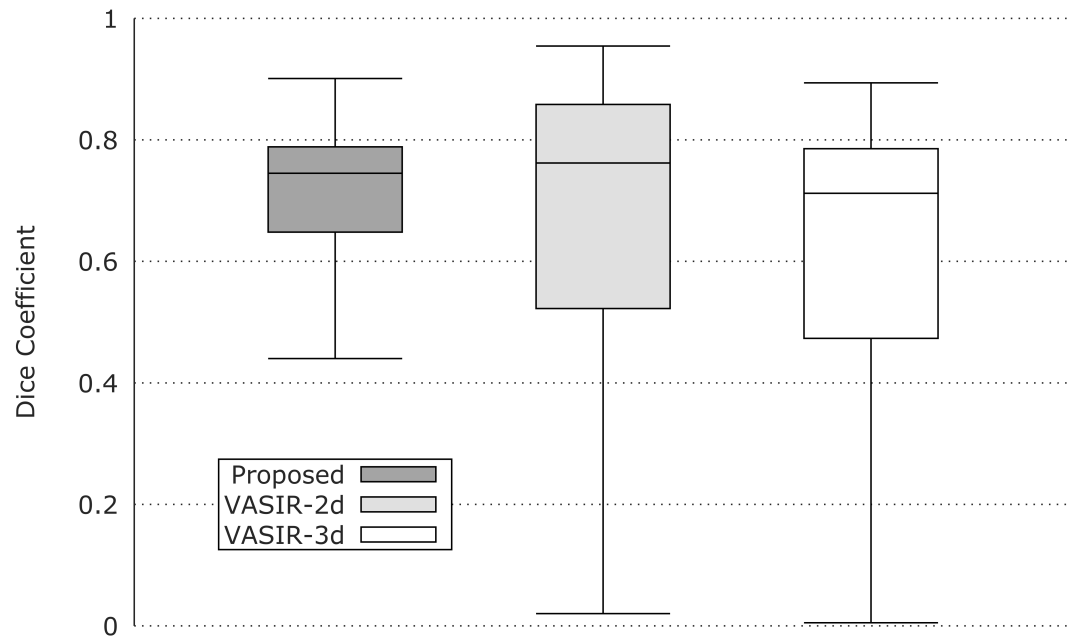
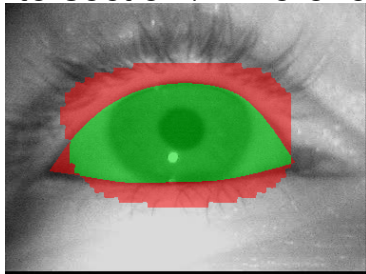
Ground Truth



Estimated



Intersection / Difference



$$DiceCoefficient [1] = \frac{2(A \cap B)}{A \cup B}$$



Real-Time Performance

Considering state-of-the-art mobile eye trackers

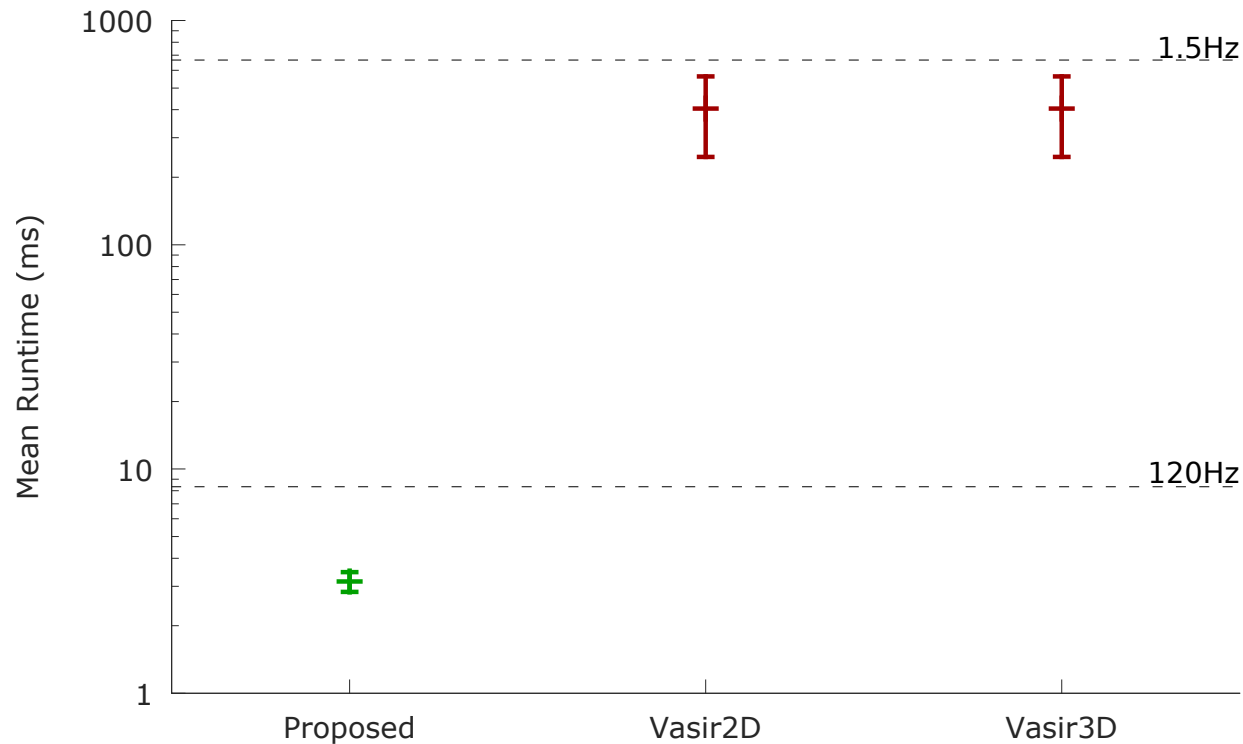
- E.g., 120 Hz – Pupil Lab's Pupil, SMI Glasses 2 [4, 3]



Real-Time Performance

Considering state-of-the-art mobile eye trackers

- E.g., 120 Hz – Pupil Lab’s Pupil, SMI Glasses 2 [4, 3]





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Conclusion

- Improved detection in real-time



Conclusion

- Improved detection in real-time
- Open data sets and code¹

¹Available at: ti.uni-tuebingen.de/perception



References I

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Thanks!

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